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References and Supplies

Books

Robert Ferencsik with Will Neptune, The Fundamentals of Fine Woodworking (Sterling 1996)

Michael Dunbar, Restoring, Tuning & Using Classic Woodworking Tools (Sterling 1989)

C.W. Hampton and E. Clifford, Planecraft (Woodcraft, 1982)

Charles H. Hayward, Cabinetmaking for Beginners (Sterling, 1979)

Charles H. Hayward, Woodwork Joints (Sterling, 1975). Out of print

R. Bruce Hoadley, Understanding Wood (Taunton, 1980)

Ernest Joyce, Encyclopedia of Furniture Making (Sterling, 1987)

Tage Frid, Tage Frid Teaches Woodworking, Book 1 & 2 (Taunton 1993)

Bernard E. Jones, ed., The Practical Woodworker (Ten Speed Press, n.d.)

Note: Woodworking titles go in and out of print frequently. These may not all be currently available.

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Suppliers -- Wood

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Bound water – found within the cells of the wood

EQ MOISTURE CONTENT 12% EMC SUMMER
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WOOD TECHNOLOGY

Wood as a Material

Wood is the structural remnant of the biological substance of a tree. It is made up of 75% cellulose, a carbohydrate and 25% lignin, a complex chemical, whose exact composition is still unknown. The cellulose forms the cell walls of the wood's long hollow fibers, and the lignin acts as a binder, a glue.

Wood is hygroscopic, that is it will absorb moisture from moist air until it reaches equilibrium with that air.

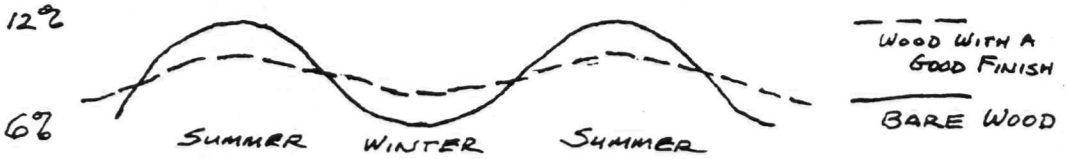
-Relative Humidity, (RH) Hot air can hold more moisture than cold air. Thus humidity is measured relative to temperature and is called relative humidity. For example, when cold winter New England air at 10% RH is let into your house where it's 68 °F, the RH of that same air is lower.

-Wood Moves When the relative humidity changes, wood shrinks or swells. When the air is drier than the board, the board will lose moisture to the air and will shrink. This happens as a newly cut log/ board dries, and also when winter comes and your dresser drawers get loose. When summer comes and the relative humidity goes up, wood swells as it absorbs moisture from the air, and those loose drawers get tight.

-Moisture content, MC The moisture content of a board, by weight versus its oven dry weight, expressed as a percentage.

Equilibrium Moisture Content, EMC The moisture content when the board is in balance with the RH of the air.

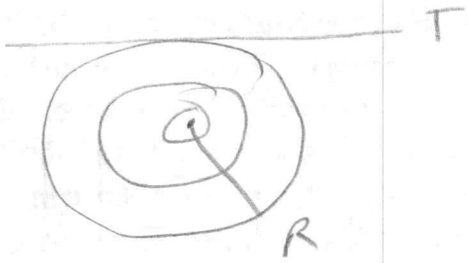
Moisture content of a board summer - winter in New England



-Lumber Drying When a tree is cut, sent to a lumber mill and cut into boards, it is *green* (wet). It contains two kinds of water, first *Free Water* , which is the water in the pore spaces of the wood. This is the H_20 in the board from green wood down to 30% MC. *Bound Water* is water found within the cell walls of the wood fibers, is slower to dry out, and goes from 29% MC down to dry (EMC); which is 12% MC in summer and 6% MC in winter in New England.

-Air Drying is done first in an open walled shed, where the wood is stickered; stacked level with evenly placed sticks between each board, so

STEAM BENDING – use air dried wood



that air can circulate freely on both sides of the board. Later, when the board is at EMC outdoors: 10-14% MC, it is brought indoors and left to come into EMC with your shop. The ends of each board are coated with wax or paint before drying.

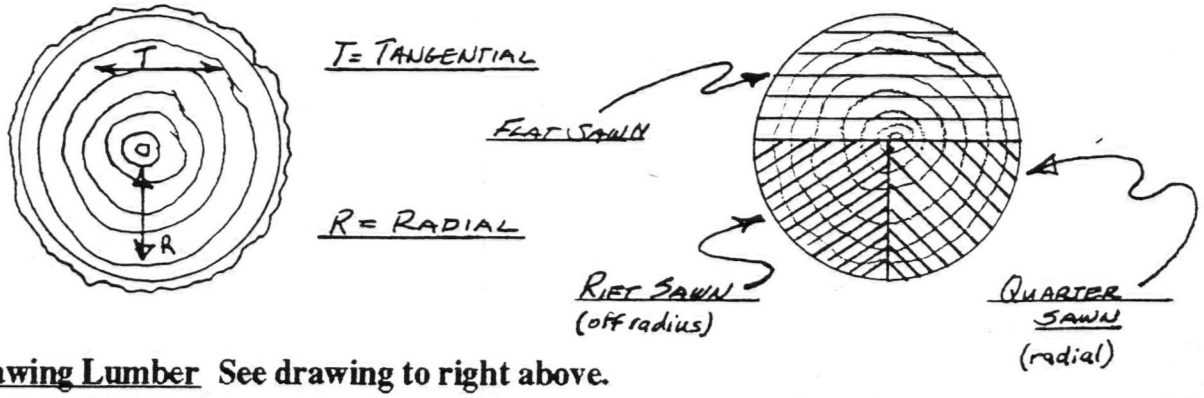
-Kiln Drying is an industrial process where the stickered, stacked lumber is put in a temperature and humidity controlled room, a kiln, and is quickly dried.

-Air Drying generally takes 1 year per inch of board thickness, and kiln drying can take as little as two weeks. Kiln drying can cause color changes in the material, and can set the lignin, causing difficulties with subsequent steam bending. This makes the boards a bit more stable.

Shrinkage As a tree dries the wood shrinks. See the drawing below and the picture in the handout from Hoadley. The wood shrinks tangentially and radially to the growth rings and negligibly in the length. The tangential shrinkage is greater. In a given kind of wood the tangential to radial shrinkage ratio (T/R Ratio) will be a fixed number. A stable wood such as mahogany will have relatively low tangential and radial shrinkage percentages, and a T/R ratio close to 1. A relatively unstable wood such as white oak will have higher shrinkage percentages, and a T/R ratio close to 2. Thus:

Species	Tangential	Radial	T/R Ratio
Mahogany	5.1	3.7	1.4
White Oak	10.5	5.6	1.8

See Hoadley, p.74.

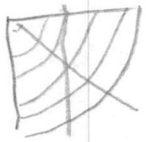


Sawing Lumber See drawing to right above.

-*Flat or plain sawn:* The tree trunk is cut "through and through", that is tangential to the cylinder of the tree trunk.

-*Quarter sawn:* The trunk is first sawn into quarters, and then

QUARTER SAWN

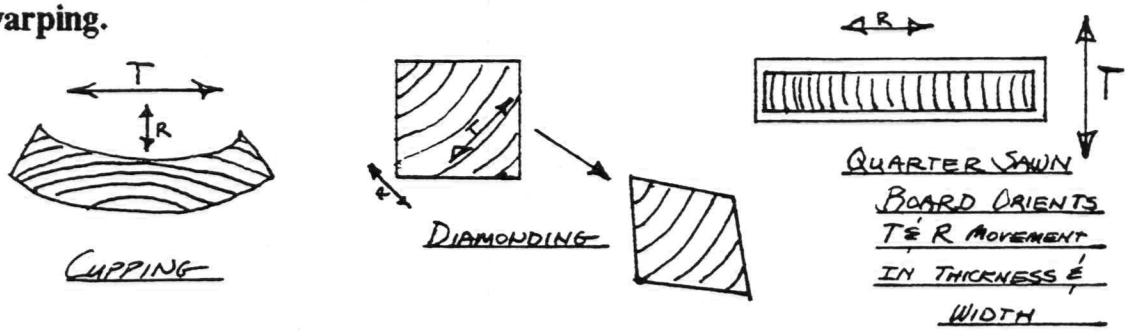


FLAT SAWN CUPS

QUARTERSAWN GOES NARROWER + THINNER
T+R MOVEMENT OCCURRED IN THICKNESS + WIDTH

each quarter is sawn perpendicular to the growth rings.
-*Rift Sawn* : Boards are sawn out at 45° to the growth rings.

Flat Sawn material *cups* , that is since the tangential shrinkage is greater than the radial shrinkage the board curls across its width as it dries. Rift sawn material *diamonds* as it dries. Quarter sawn material shrinks tangentially and radially, and since these shrinkages are in the dimensions of thc board, the board stays flat, but gets narrower and thinner. This is the *most stable way* of sawing, and is the best way of sawing unstable woods. *Checking* is when the wood cracks radially because too much shrinkage induced stress is present to be released by warping.



Warp is distortion from the intended shape of a board. Types:

Cup is warp across the width of a board.
Bow is warp in the thickness along the length of a board.
Crook is warp in the width along the length of a board.
Twist or Wind is a complex combination of cup and bow in a board such that two corners diagonal to each other are high and the two others are low. This is the most difficult type of warp to remove.

Joinery & Construction

These have been developed to strongly assemble pieces of wood yet allow for seasonal wood movement.

Lumber

Wood comes from trees of which there are two basic types:

Hardwood trees are angiosperms, plants with encased seeds. They are biologically diverse, numerous, evolutionarily advanced, and are dominant on the planet. The trees tend to be deciduous (that is they lose their leaves in the fall) and the form of the tree is dendritic, that is branching and rebranching from the initial crotch. The wood is often dense and hard.

Softwood trees are gymnosperms, plants with naked seeds. These trees are less diverse, though there are large temperate softwood forests, and they are evolutionarily primitive. They are declining in number and species biologically versus the angiosperms. The trees tend to be evergreen, and the form of the tree is more or less conical or excurrent, where the branches radiate from a long central trunk. The seeds are borne in cones, and the wood is relatively low in density.

Rough Lumber Lumber for furniture is sold in the rough, that is as it was sawn out of the log in the mill before drying. Hardwood lumber is *graded* differently from softwood lumber, and the grading varies with the species even within the two general classifications.

Hardwood Grading:

-*Pattern Grade* : clear, even grained stuff, sometimes light in weight and color, but often wide boards.

-*First and Seconds(FAS)* : the best grade available in all species, clear and usually even grained.

-*Select or Select and Better (S&B)* : A fair grade, but more defects than those above.

-*Common* : More defects still, but sometimes nice, figured, dense stuff in mahogany.

Softwood Grading (Briefly):

-*C or D and Better (C select, &D select)* : Clear boards, widths and lengths vary with species.

-*Common* (#1 Common, #2 Common): Not clear, can contain *pith* , the original stem of the tree, and is called *knotty* when #2 common.

Rough Lumber is sold by volume. That is it is sold by the *board foot* , which is 144 cu. in. It is sold also in *random widths and lengths RWL* . It is classified in thickness by quarters, those commonly available are: 4/4 (1"), 5/4 (1-1/4"), 6/4 (1-1/2"), 8/4 (2"), 10/4 (2-1/2"), 12/4 (3"), 16/4 (4"), 20/4 (5").

Heartwood is the dead structural wood in the central part of the tree trunk. It contains extractives: chemicals that give the wood a dark color, more density, and rot resistance.

Sapwood is lighter in color and weight, is found in the outer area of the tree trunk, still conducts water from the roots to the leaves, and has some living (ray) cells.

Figure

Ray Fleck: the flat bands of rays exposed on quarter sawn surfaces such as in quartered oak or lacewood.

Crotch Figure: The swirly patterns produced at the crotch (first branching) of the trunk of a tree.

Curly figure when the grain grows in waves. May be *tiger stripe* or *fiddle back* when the waves are tight, or *chatoyancy* (having a luster like silk) as in looser curly (ropey) cherry or birch.

Interlocked or spiral grain will result in *ribbon* figure in mahogany.

Blister figure is where small round 'lumps' of grain protrude into the next year's growth. *Quilted figure* is where larger amorphous lumps randomly do the same thing. These are common in sugar maple Acer sacharrum and bigleaf maple Acer macrophylla respectively.

Burl is a confused mixture of buds and normal wood with a random grain direction. Burls are found growing out from the side of the trunk near the base of the tree. Redwood and maple are common burls.

Birdseye is a tiny ~~small~~ swirl of grain direction commonly found in clusters in maple.

Spalting is arrested rot, and results from stains left in the wood by advancing fungi. It can be very toxic to the wood worker when worked in air dried form, because the fungal spores are alive.

John P. McCormack 10/27/'95 © JPM/NBSS

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Hoadley, R. Bruce, Understanding Wood, A Craftsman's Guide to Wood Technology, Newtown, Connecticut, The Taunton Press, 1980.

Neptune, Will, Lecture Notes, Fundamentals of Fine Woodworking I, A course developed by him and taught at The North Bennet Street School, 1992.

MILLING

The first principle in understanding milling is the development of reference surfaces. There are two of these, and they are the reference face and edge. Both are produced on the jointer. All other planar surfaces are dependent on these both for their existence and accuracy. The six surfaces of a rectilinear board are developed differently depending if you are doing it by hand or machine. These steps are described below. The reference surfaces are indicated by a *.

Handtool Method

*** 1. Handplane face flat and mark.**
- **No cup.**
- **No bow.**
- **No wind**

*** 2. Handplane edge and mark it.**
- **Square to face.**
- **Straight and flat.**

3&4. Handplane ends (x 2)
- **Square to face**
- **Square to edge**

5. Handplane other edge
- **Rip rough width if nec.**

6. Handplane other face

Machine Method

*** 1. Joint face**
- **Mark face.**
- **Mark grain runout.**

2. Plane other face.
- **Jointed (ref.) face goes down against planer table.**

*** 3. Joint edge.**
- **Square to reference face.**
- **Mark it.**

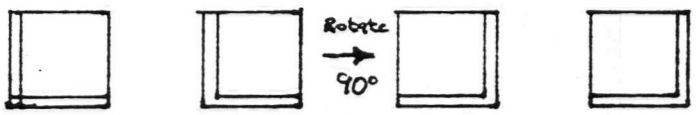
4. Rip edge to width.

5&6. Crosscut ends to length

In roughing out your boards, first the end checks are cut out. Then, the boards are cut 1" longer and 1/2" wider than their final dimension. Depending on the material and the length of your parts, buy material 1/4" thicker than the final thickness.

There is a term called double milling. That is you mill your boards 1/8" over thickness (Machine steps 1 & 2 only) and (Handplane steps 1 & 6 only), sticker them overnight, and do all the steps the next day to final dimensions.

Legs that are square in cross section have two jointed reference faces and two planed faces:



REF. FACES (jointed) ⊏. These stay against planer table.

Planed faces are secondary faces, and depend on the ref faces for their accuracy.

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All 4 planed faces go thru planer @ same height setting on the last pass.

The workpiece

The aspects of wood that affect machining have already been covered in previous chapters. The structural nature of wood in terms of its three-dimensional properties is particularly important. Density variation among and within species is also of obvious importance, as is unevenness of grain, especially in ring-porous hardwoods and uneven-grained softwoods. Heartwood extractives in some species are particularly abrasive and contribute to tool dulling. Defects such as knots create both irregularities of grain direction and variations in density. Structural irregularities such as wavy or interlocked grain cause special machining problems. Moisture content influences machining as it affects the strength of wood, and so do stresses or checks developed in drying.

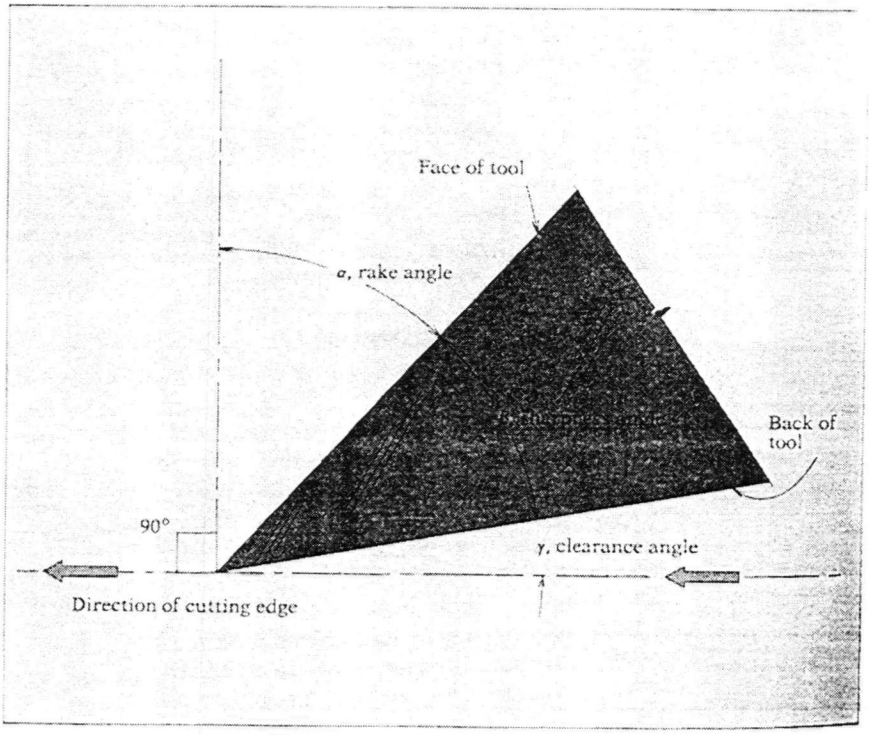
Strength of wood is, of course, the bottom line. The relationship between the strength of wood parallel to the grain and perpendicular to the grain is perhaps the most important part, although every other factor affecting strength in turn affects machining.

The tool

At the business end of a cutting tool, where chips are being formed, the tool geometry can be described in terms of a **cutting edge** formed by its intersecting **face** and **back** surfaces, or planes *(1)*. The critical geometry of the cutting edge is usually defined in terms of its direction of motion:

- α = the **rake angle** (also called the **cutting angle**, the **hook angle**, the **chip angle** and the **angle of attack**) is the angle between the tool face and a line perpendicular to the direction of travel of the edge.
- β = the **sharpness angle**, the angle between the face and back of the knife.
- γ = the **clearance** angle, the angle between the back of the knife and the direction of travel of the edge.

As required by circumstance, cutting-tool geometry can be varied considerably. The sharpness angle will always be a positive value. The cutting angle and clearance angle can be negative values. In the case of the clearance angles, negative values indicate interference between tool and workpiece.



1—The business end of a cutting tool consists of an edge formed by its intersecting face and back surfaces. Its geometry can be described by the rake angle, α (alpha), measured from a line perpendicular to the direction of travel to the tool face; the sharpness angle, β (beta), measured between the face and back of the tool; and the clearance angle, γ (gamma), measured between the back of the knife and its direction of travel.

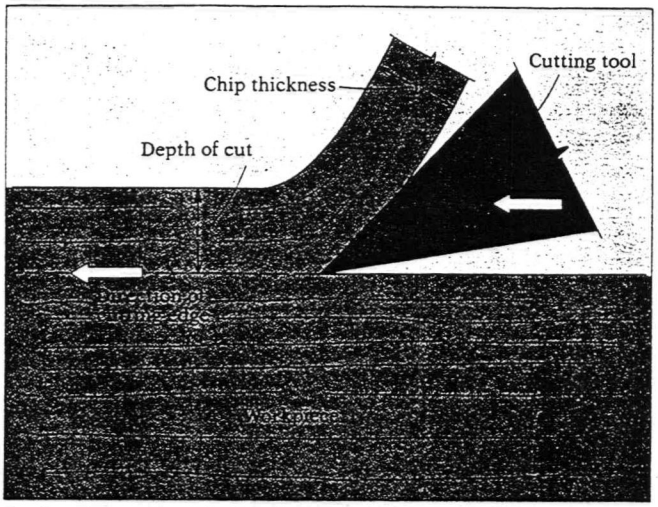
Chip formation

Figure 2 shows an ideal cutting action, which will vary according to the resisting grain orientation of the wood and the tool geometry. Energy is consumed in severing or separating the wood structure to form the chip, in deforming or rotating the chip, and in the frictional resistance of the tool face against the chip and the tool back against the newly formed surface of the workpiece. Each element varies in importance, depending on the type of cutting. In riving shakes, for example, after initial entry of the cutting edge and initiation of the split, the chip forms by fiber separation well ahead of the knife edge, with energy being expended to overcome friction on both sides of the knife and to deform (usually by bending) the chip being separated. In planing wood across the grain, the edge of the iron severs cell structure with minimal frictional resistance from the weak chip being separated. When the resulting shape and surface quality of the workpiece are important, it is critical to keep chip formation close to the tool edge itself. When the chip is being formed well ahead of the tool, as in splitting wood, neither its shape nor its surface quality can be well controlled.

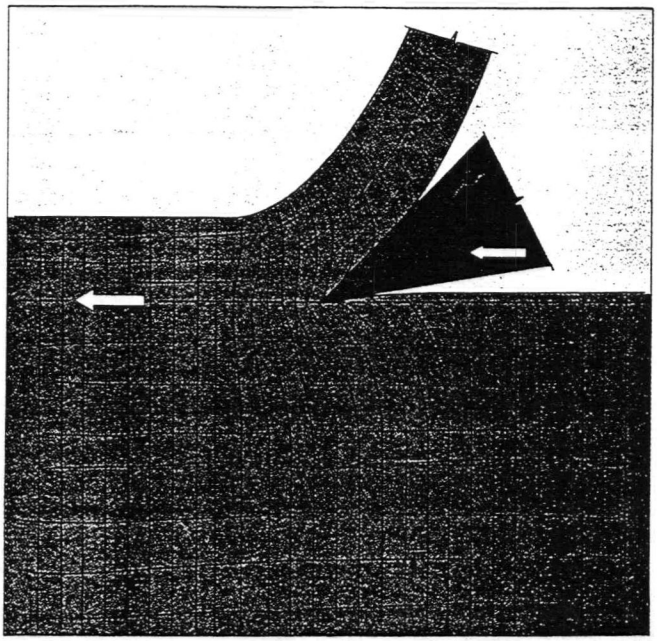
In cutting-tool design, a compromise must often be made. It would seem advantageous to increase the cutting angle and reduce the sharpness angle, thereby reducing the amount of distortion of the chip and the resulting forces against the tool. In practice, however, one soon runs up against the limitations of steel. Such an idealized cutting edge would have little strength, and would soon break or become dull. Increasing the sharpness angle of the tool makes the edge more durable, but eventually leads to excessive frictional resistance or to uncontrollable chip formation.

When severing wood tissue with an edge, two points must be kept in mind: First, failure occurs only when ultimate stress is reached; second, stress is *always* accompanied by strain. This means that contrary to the idealized cutting action shown in Figure 2, we must imagine something else, where in order to develop enough stress to produce failure, the wood must first deform *(3)*. Considered another way, since stress is load divided by area, then the smaller the area of application, the higher the stress that will be produced by a given load. We should therefore try to concentrate cutting force on the smallest possible area.

This, of course, is what we commonly call sharpness. Most people think of sharpness as the minuteness of the cutting edge, which influences the relative force required in cutting. But one must also think of sharpness or dullness in terms of the deformation of the wood tissue in both the chip and the workpiece. A helpful model for visualizing this relationship is to try to take a ⅛-in. slice from the edge of a wet cellulose sponge with an ordinary table knife. The sponge simply moves out of the way, and no cutting is done. With a very sharp knife or razor blade the sponge can be cut, but only after it deflects noticeably ahead of the knife. "Chip formation" is irregular. Some sponge may tear away in places other than at the exact blade edge. When the "chip" of sponge is finally severed, the "workpiece" springs back, and an irregular surface is the result, because of the irregular deflection. The springback of material after the cutting edge passes also illustrates the need for an appropriate clearance angle.



2—Cutting action idealized. Energy is consumed in severing the wood to form the chip, in deforming or rotating the chip, and in friction of the tool face against the chip, plus friction of the tool back against the new surface of the workpiece.

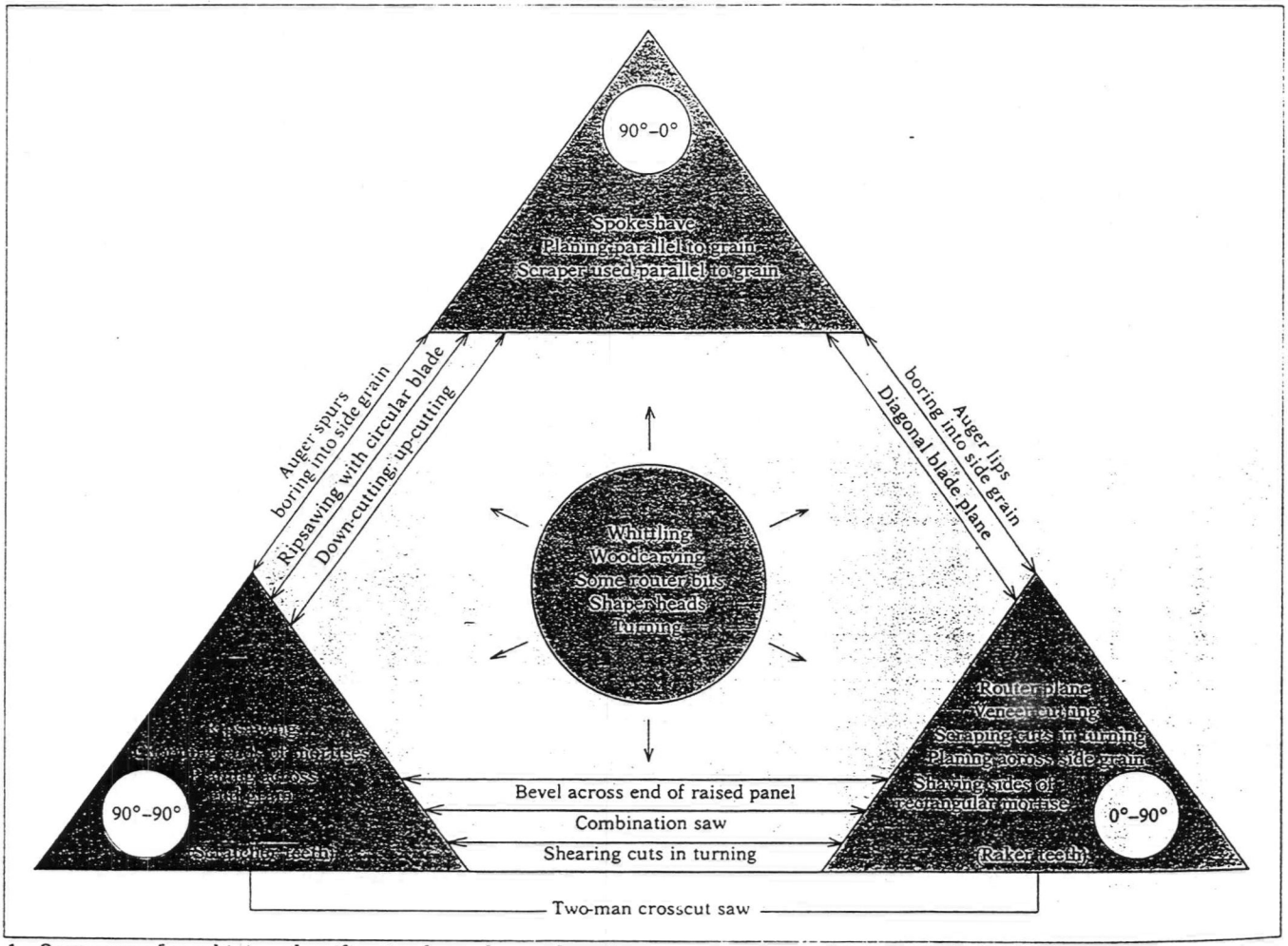


3—Cutting action in reality. The wood does not fail until ultimate stress is reached, and stress is always accompanied by strain. As the cut proceeds, the workpiece deforms ahead of the tool, severs, and then both workpiece and chip spring back to some extent.

Combination and compromise

In summary *(1)*, some forms of machining such as veneer cutting, hand-planing and ripsawing are virtually pure cases of orthogonal cutting. Some tools, such as the two-man crosscut log saw, involve a combination of cutting modes. But many involve cutting action that is a compromise between two types (for example, planing the bevel across the end of a raised panel) or which varies between two types (as in ripsawing with a circular blade raised to different heights, or the spurs of an auger through each half-revolution).

Some aspects of woodworking involve all conceivable interactions and combinations. Woodturning and woodcarving are good examples where every imaginable combination of wood structure and cutting direction seems eventually to present itself. I realize this every time I scoop out a wooden bowl or hollow out a decoy body. By experience the woodcarver develops an intuition for the best cutting action or compromise to use in a given situation. By intuition, the workpiece is turned this way and that from cut to cut, to favor 90°–0° cutting with the grain and to avoid the costly splits of carving against the grain. There would be no value in attempting to analyze every cut in terms of orthogonal cutting or tool geometry. But the better the various types of cutting action are understood, the more successfully intuition will be developed. And oftentimes, when a chronic machining problem such as torn side grain or scuffed end grain seems insoluble, careful analysis of the cutting action will suggest whether the problem is one of depth of cut, cutting angle or tool sharpness.



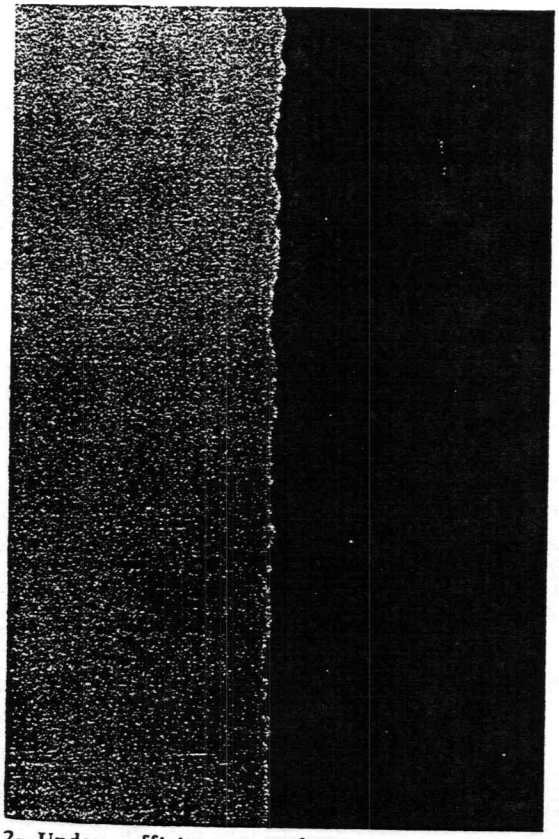
1—Summary of machining classification by orthogonal cutting type.

Sharpening

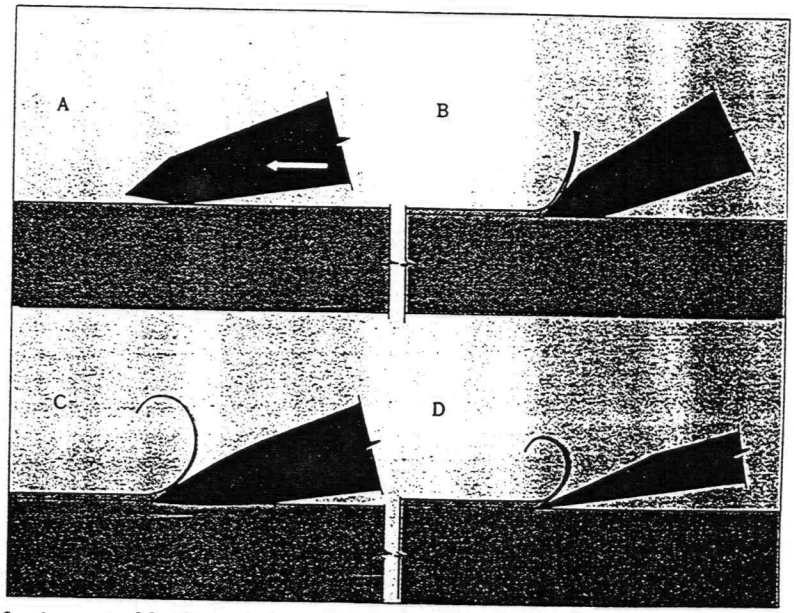
To me, the term **sharpness** includes two things. The first is the condition of the cutting edge, that is, how well the face and back surfaces combine to form a line of intersection. The closer the face and back approach true planes, the more closely the cutting edge approaches a straight, not irregular, line. Of course, no matter how well the edge is formed, if magnified enough, it will look like a mountain range *(2)*. The second aspect of sharpness is correct tool geometry. A sharp edge is of little use if it is not associated with suitable cutting, sharpness and clearance angles.

A common example is the ordinary pocketknife *(3)*. It is usually sold with polished blades, with narrow factory-ground faces forming a cutting edge that includes a large sharpness angle. The cutting edge may be well formed, and it may readily cut your finger. But the tool geometry is all wrong for cutting wood. Try a typical paring cut and the knife won't work at all. It just slides along the wood surface. Held in the usual position, the negative clearance angle prevents cutting. If the blade is rotated enough to eliminate the negative clearance, the rake angle becomes so small that the knife cuts poorly, with too much force required. The sharpness angle is simply too great. Its geometry must be corrected so that the cutting edge contacts the wood (that is, the clearance angle is zero or greater) when the knife is held in a comfortable position, and the sharpness angle must be reduced. For utility cutting toward and away from you, lengthening both faces is one compromise. For whittling with a jackknife in the traditional draw-grip position, I like to keep the side of the knife that contacts the wood flat, and do all my sharpening on a bevel on the other side.

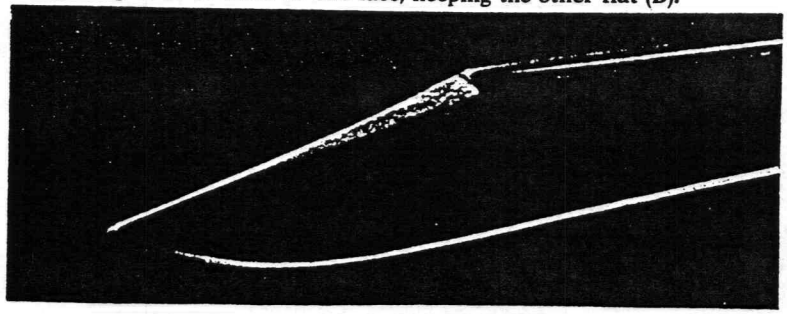
One of the greatest difficulties in sharpening is keeping flat faces. Since two problems are worse than one, I always try to keep one face of an edge flat, and sharpen the other to the correct geometry. This way I have only one side to work on and one side to correct if I get it



2—Under sufficient magnification, even a razor-sharp plane iron has a jagged edge.



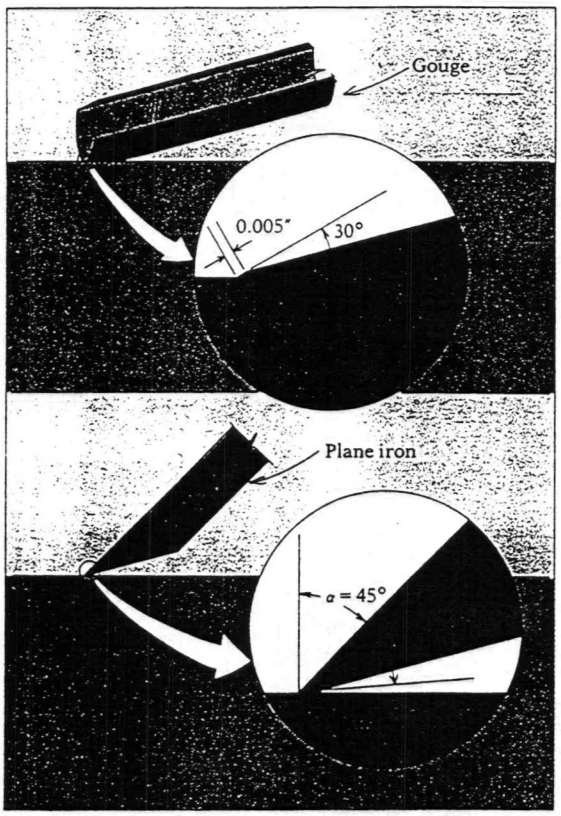
3—A new jackknife sometimes won't cut wood when held normally because its large sharpness angle results in a negative clearance angle (A and in the photo below). When rotated to eliminate the negative clearance angle (B), the cutting angle is so small that chip formation is difficult. Both faces of the blade must be lengthened to reduce the sharpness angle (C), or all the sharpening must be done on one face, keeping the other flat (D).



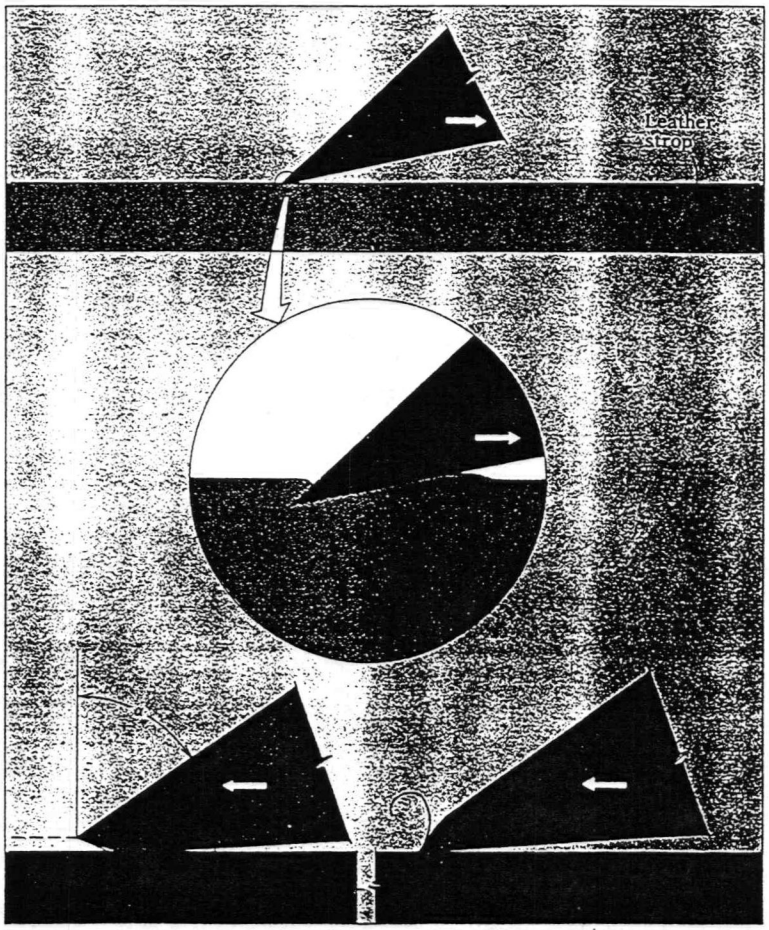
fouled up. (Some tools, such as a standard ax, for example, must be sharpened on both faces.)

Woodcarving chisels usually form the cutting edge with a single beveled surface, as is the case on the outside bevel of a typical gouge. The bevel thus becomes the back surface as used in carving. The chisel is actually guided by its back surface, so an effective 0° clearance angle results. It is not critical that the back bevel be absolutely flat, and in hand-sharpening a slight belly invariably develops. Common sense will suggest the degree of flatness the bevel must have as it merges with the edge to form the actual sharpness angle.

Another concept the woodworker can use to advantage is **microsharpening**, that is, increasing the sharpness angle near the very edge of the cutting knife. Most cutting geometry (a carving chisel and a jackknife are good examples) is a compromise between maximizing the rake angle for ease of cutting and maximizing the sharpness angle for a durable edge. Further, degradation of the cutting edge (dulling) begins at the very apex of the edge and works back from there. Microsharpening offers an interesting tradeoff by increasing the sharpness angle at the very edge, where it is needed for durability, without appreciably changing the rake angle in the area associated with rotation of the chip. On a woodcarving gouge, for example, a sharpness angle of 15° can be strengthened to 30° by a microbevel of 0.005 in. with almost imperceptible change in the cutting resistance *(1)*. With a standard bench plane whose iron is set at a rake angle of 45° and sharpened to about 30°, the sharpness angle can be microbeveled to about 40°, still leaving a clearance angle of 5° or so for good measure. Plane-sharpening instructions often refer to this as the "honing angle." The moderate jointing of



1—Microsharpening creates a larger sharpness angle near the edge (for greater durability) without significantly affecting chip formation. Shown are a microsharpened gouge and a microsharpened plane iron.



2—Stropping the cutting edge against a non-rigid surface like leather probably causes a slight rounding near the edge. Stropping on the face bevel instead of on the back ensures that the cutting edge remains the lowest point on the tool, and that the clearance angle is never less than 0°.

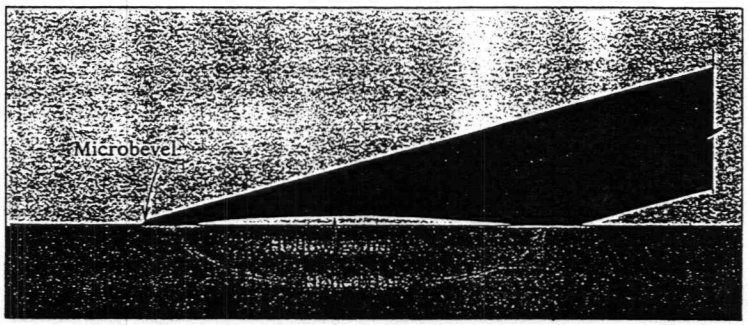
planer knives is also microsharpening. Once again, microsharpening must not produce a negative clearance angle; the cutting edge must always be the deepest part of the tool.

When a blade is stropped on a non-rigid surface like leather, I can't believe the faces are not altered at the very edge. I visualize something such as shown in Figure 2. This slightly rounded spear-pointing may then in effect be equivalent to microsharpening. With this in mind, I try to bias my stropping to favor heavier removal on the face than on the back of the edge.

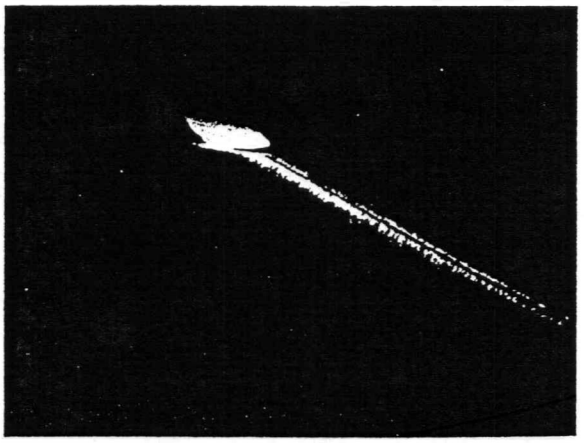
While it is tempting to let this discussion wander over into techniques of sharpening, that subject is beyond the scope of this book. But I can't resist adding a few comments. First, the quality of the tool face and back, and therefore of the edge formed at their intersection, is closely related to the scratch pattern left by whatever abrasive was used to do the sharpening. Needless to say, deep scratches leave larger, fragile projections at the edge, and breakage of larger projections causes faster dulling. The finest abrasives leave the shallowest scratch patterns and a more durable as well as a "sharper" edge. Most woodworkers agree that Arkansas stones produce the finest and truest possible edge surfaces.

A certain mystique has been created around the notion of **hollow grinding**. I suggest it be looked at in terms of tool geometry. Hollow grinding gives a greater clearance where the back bevel is restricted, as with a planer knife. But it also reduces the sharpness angle, sometimes too much. In the case of a planer knife, a slight jointing takes care of this. I see hollow grinding as a convenient partner to microsharpening. In sharpening carving tools, for example, I like to hollow-grind the bevel *(3)*. This establishes a basis for the sharpening and honing angles which I like to do by hand on flat stones, adding a final microbevel with a hard Arkansas pencil and stropping lightly with a piece of notebook paper. The hollow grinding narrows the area to be stone-sharpened to the edge and heel of the back. It also reduces friction in cutting *(4)*.

Experienced woodworkers agree that sharpening is important. The beginner too often is slow to acknowledge this reality. The beginning woodcarver always asks "Which tools should I buy first?" My stock answer, "A set of good stones," is seldom received with joy. Experience with dull and really sharp tools, however, quickly confirms that tools are almost worthless if they cannot produce the desired cutting action.



3—To sharpen a carving chisel, Hoadley first hollow-grinds the bevel against an abrasive wheel, then hones the bevel, first with a fine India stone followed by a hard Arkansas stone, to produce flats at the tip and heel of the bevel. Next the face is microbeveled, followed by a light stropping, mainly of the face microbevel.



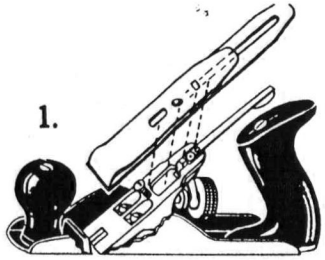
4—A gleaming bevel is the hallmark of well-sharpened carving tools.

From: R. Bruce Hoadley, Understanding Wood (Taunton Press, 1980). Photocopied with permission of the Taunton Press.

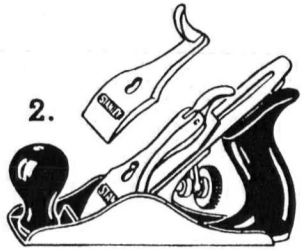
STANLEY

HOW TO SET THE STANLEY PLANE

STANLEY

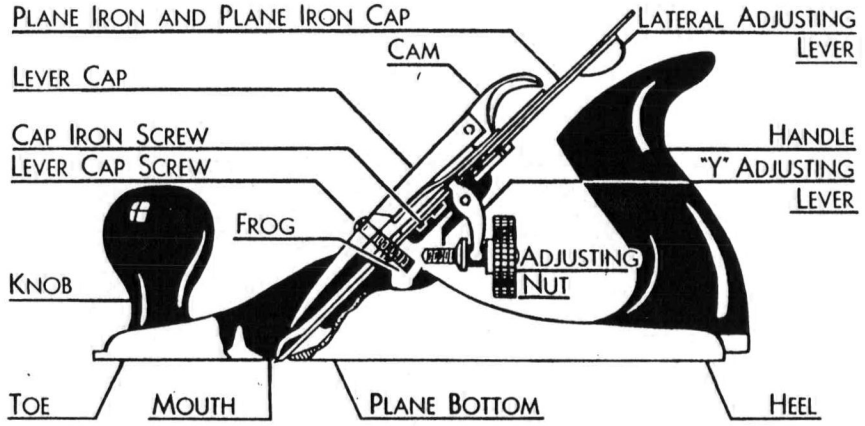


TO PUT THE PLANE TOGETHER LAY THE PLANE IRON, BEVEL SIDE DOWN, ON THE FROG. BE SURE THE ROLLER ON THE LATERAL ADJUSTING LEVER, THE END OF THE "Y" ADJUSTING LEVER AND THE HEAD OF THE PLANE IRON CAP SCREW ARE CORRECTLY SEATED.



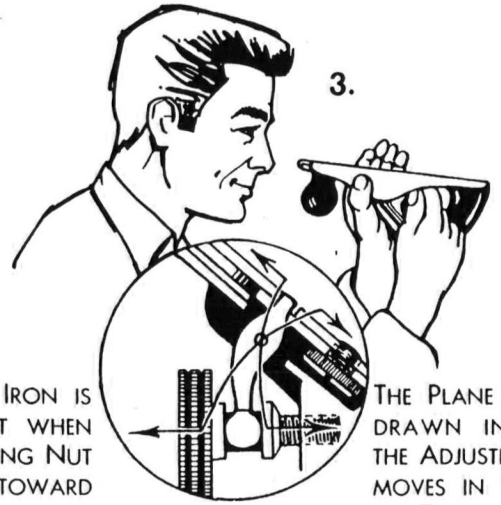
SLIP THE LEVER CAP UNDER THE LEVER CAP SCREW AND PRESS DOWN THE CAM. IF THE PLANE IRON IS IN THE CORRECT POSITION THE CAM WILL EASILY SNAP IN PLACE. IF THE CAM WILL WILL NOT SNAP IN PLACE EASILY, SLIGHTLY LOOSEN THE LEVER CAP SCREW.

IF THE PLANE IRON, IS NOT FIRMLY HELD WHEN THE CAM IS IN PLACE SLIGHTLY TIGHTEN THE LEVER CAP SCREW.



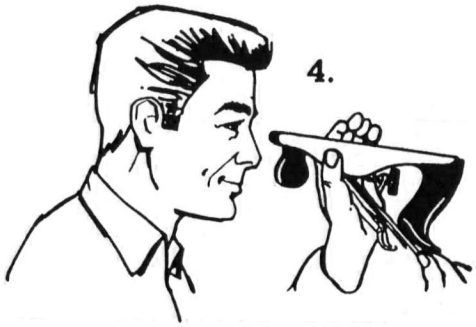
STANLEY NO. 4 OR 5

TO ADJUST FOR THE THICKNESS OF THE SHAVING SIGHT ALONG THE BOTTOM OF THE PLANE AND TURN THE ADJUSTING NUT UNTIL THE CUTTING EDGE PROJECTS ABOUT THE THICKNESS OF A HAIR.

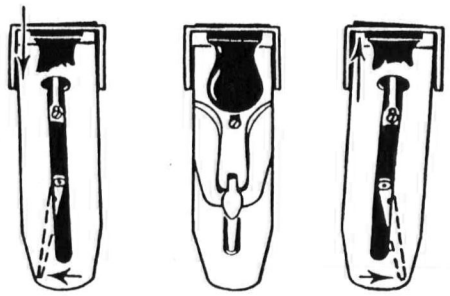


THE PLANE IRON IS PUSHED OUT WHEN THE ADJUSTING NUT MOVES OUT TOWARD THE HANDLE.

THE PLANE IRON IS DRAWN IN WHEN THE ADJUSTING NUT MOVES IN TOWARD THE FROG.



TO ADJUST FOR THE EVENNESS OF THE SHAVING SIGHT ALONG THE BOTTOM OF THE PLANE AND MOVE THE LATERAL ADJUSTING LEVER TOWARD THE RIGHT OR THE LEFT.



KNOB, LEVER CAP AND PLANE IRON CAP REMOVED TO SHOW THE ACTION OF THE LATERAL ADJUSTING LEVER.

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STANLEY PLANES

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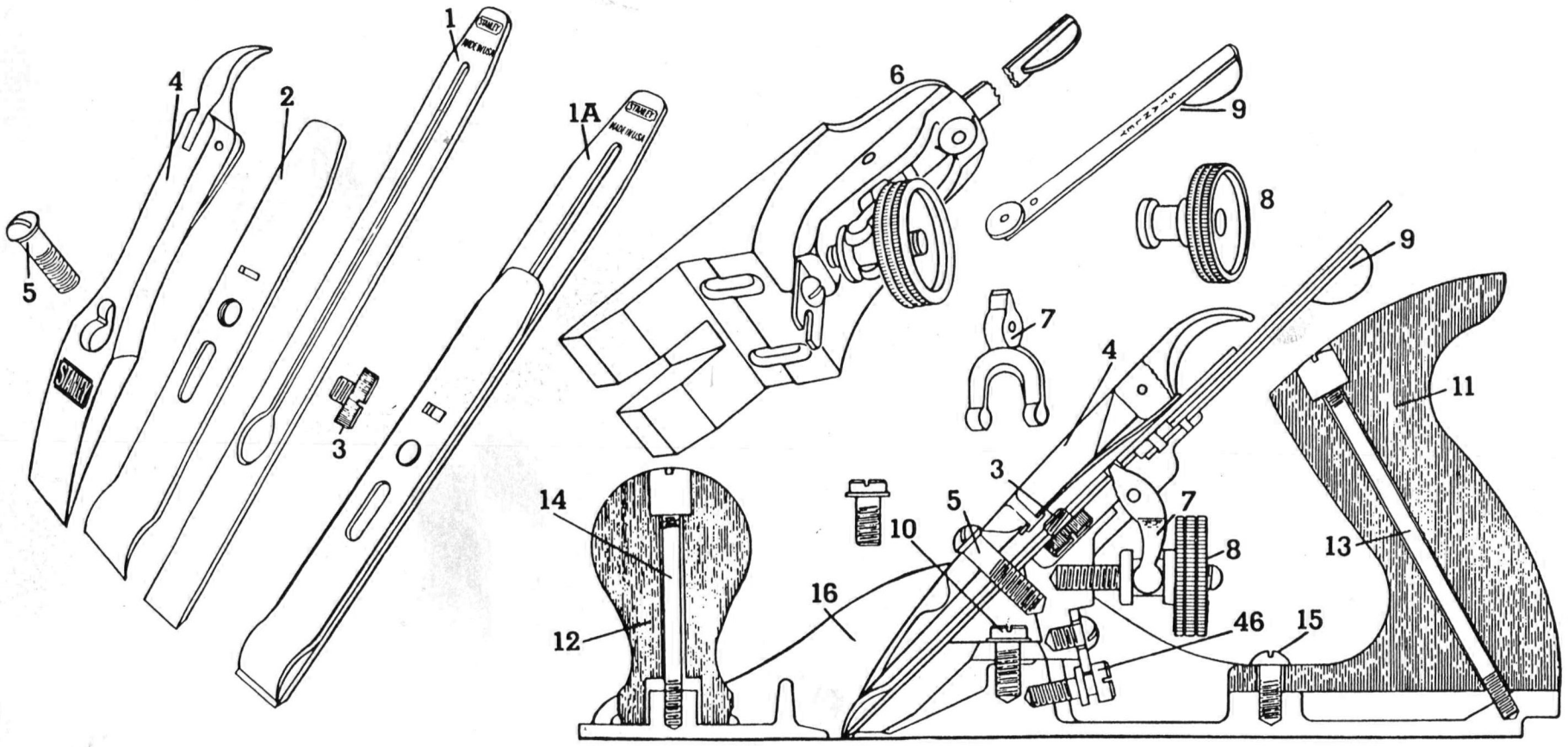

1A	DOUBLE PLANE IRON	**4**	LEVER CAP	**9**	LATERAL ADJUSTING LEVER	**14**	KNOB BOLT & NUT
1	SINGLE " "	**5**	" " SCREW	**10**	FROG SCREW	**15**	HANDLE SCREW
2	PLANE IRON CAP	**6**	FROG COMPLETE	**11**	HANDLE	**16**	BOTTOM
3	CAP SCREW	**7**	"Y" ADJUSTING LEVER	**12**	KNOB	**46**	FROG ADJUSTING SCREW
		8	ADJUSTING NUT	**13**	HANDLE BOLT & NUT		

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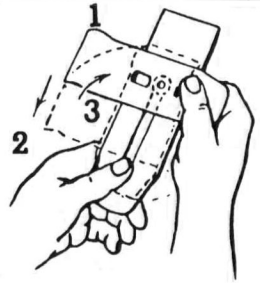
STANLEY

HOW TO ASSEMBLE THE

STANLEY DOUBLE PLANE IRON

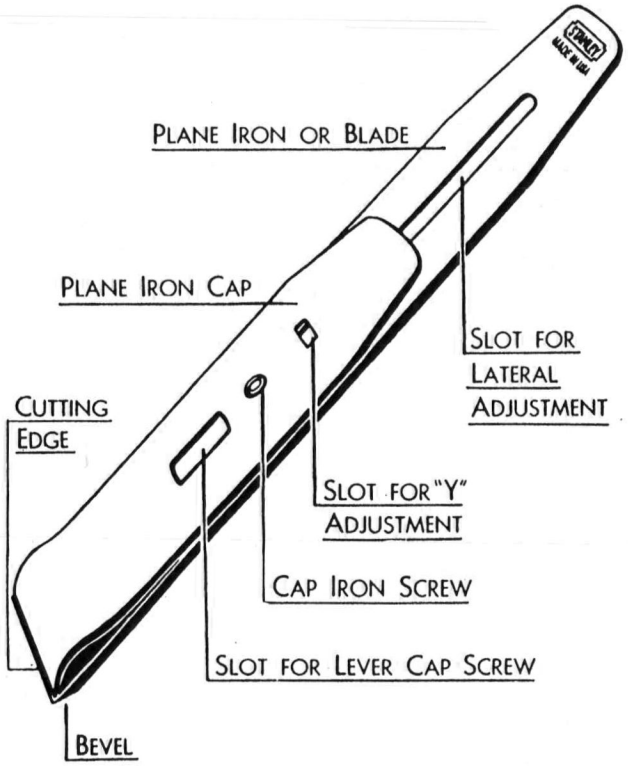
STANLEY

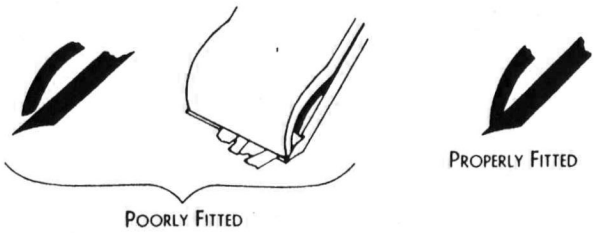


TO PUT THE PLANE IRON AND THE PLANE IRON CAP TOGETHER. 1—LAY THE PLANE IRON CAP ON THE FLAT SIDE OF THE PLANE IRON, AS SHOWN, WITH THE SCREW IN THE SLOT. 2—DRAW THE PLANE IRON CAP BACK. 3—TURN IT STRAIGHT WITH THE PLANE IRON.

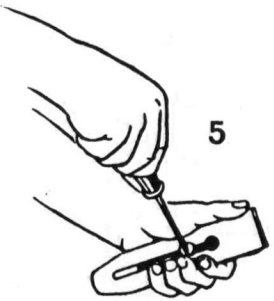
4—ADVANCE THE PLANE IRON CAP UNTIL THE EDGE IS JUST BACK OF THE CUTTING EDGE OF THE PLANE IRON. THE PLANE IRON CAP MUST NOT BE DRAGGED ACROSS THE CUTTING EDGE.

THE PLANE IRON CAP SHOULD EXTEND 1/16" BACK OF THE CUTTING EDGE FOR GENERAL WORK. ON CROSS GRAINED OR CURLY WOOD IT SHOULD BE AS NEAR TO THE CUTTING EDGE AS POSSIBLE.

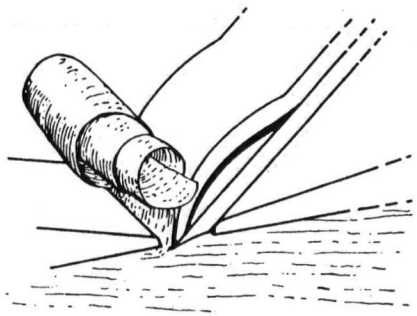




EDGE OF PLANE IRON CAP MUST FIT TIGHT TO PREVENT SHAVINGS WEDGING UNDER IT, PILING UP AND CHOKING THE PLANE.



5—HOLD THE PLANE IRON AND THE PLANE IRON CAP FIRMLY AND TIGHTEN THE SCREW TO HOLD THE TWO PARTS TOGETHER.



THE PLANE IRON CAP BREAKS AND CURLS THE SHAVING. TOGETHER WITH THE TOE OF THE PLANE IT PREVENTS THE WOOD SPLITTING AHEAD OF THE CUTTING EDGE, PRODUCING A SMOOTH SURFACE. THE PLANE IRON CAP ALSO SERVES TO STIFFEN THE PLANE IRON.

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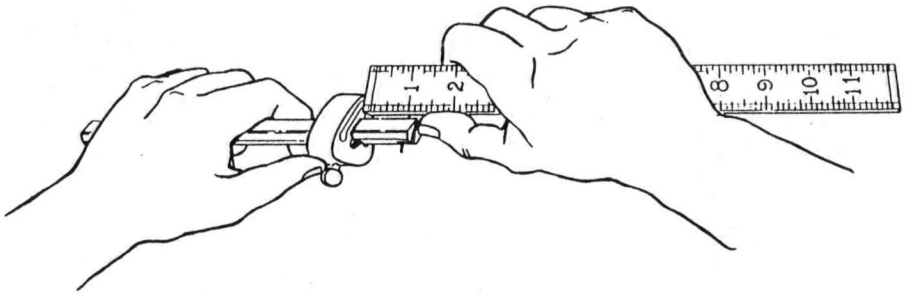
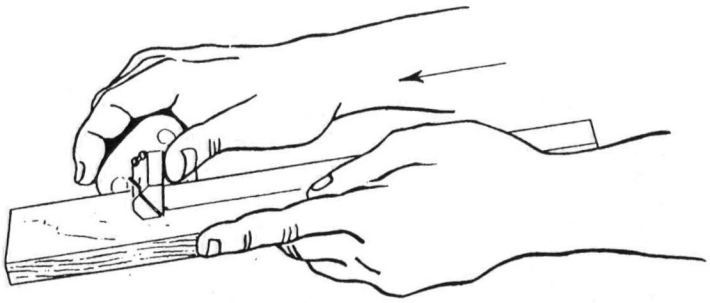
HOW TO USE THE

STANLEY MARKING GAUGE

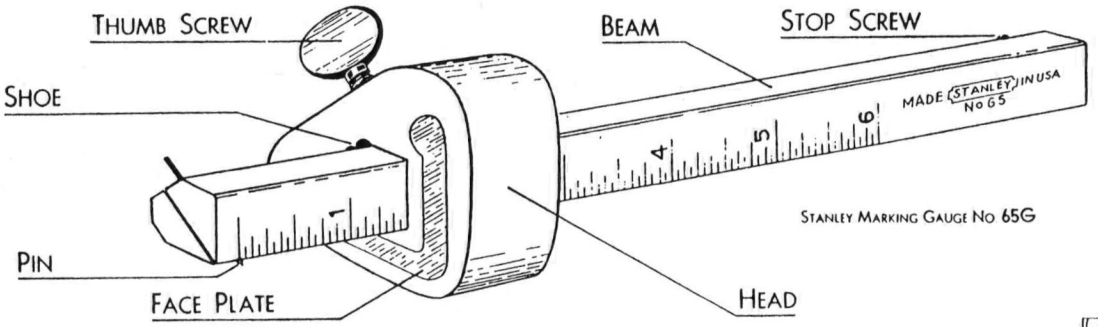
STANLEY



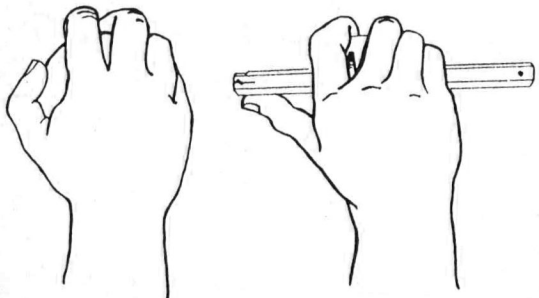
SET THE MARKING GAUGE BY MEASUREMENT FROM THE HEAD TO THE PIN. CHECK THE MEASUREMENT AFTER TIGHTENING THE THUMB SCREW.



LAY THE BEAM FLAT ON THE WOOD SO THE PIN DRAGS NATURALLY AS THE MARKING GAUGE IS PUSHED AWAY. NO ROLL MOTION IS NECESSARY. THE PIN AND LINE ARE VISIBLE AT ALL TIMES.



STANLEY MARKING GAUGE No. 65G

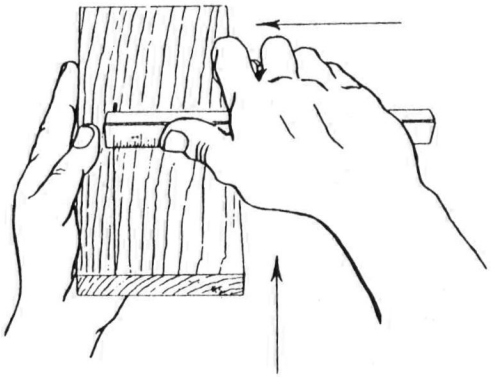


HOLD THE GAUGE AS YOU WOULD A BALL.
ADVANCE THE THUMB TOWARD THE PIN SO AS TO DISTRIBUTE THE PRESSURE EVENLY BETWEEN THE PIN AND THE HEAD.

THE PIN SHOULD PROJECT ABOUT 1/16 IN. THE CURVED SIDE OF THE PIN HELPS TO KEEP IT FROM FOLLOWING THE GRAIN OF THE WOOD.

TO MAKE A GAUGE LINE PUSH THE GAUGE FORWARD WITH THE HEAD HELD TIGHT AGAINST THE WORK EDGE OF THE WOOD.
THE PRESSURE SHOULD BE APPLIED IN THE DIRECTION OF THE ARROWS.

THE PIN IS GROUND WITH A CONICAL POINT THEN ONE HALF IS GROUND FLAT. THIS GIVES A KNIFE TYPE LINE.



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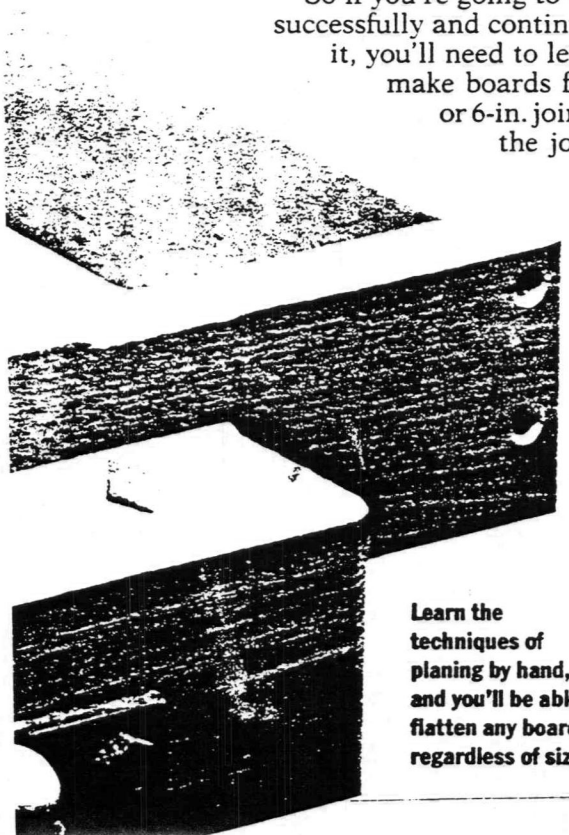
BOARDS BENCH PLANE

Discover the Pleasures of Doing It by Hand

BY ROGER HOLMES

You don't have to work with wood very long to discover that few of the boards you buy are flat. It doesn't matter whether they come surfaced on two sides (S2S) from the local building supply or roughsawn from a lumber mill. Nor does it take long to find out how frustrating it is to work with boards cupped across their width or bowed or twisted along their length. Joints are difficult to lay out and cut, and assembly is a struggle, generally won only by brute force and well-chosen words.

So if you're going to work wood successfully and continue to enjoy it, you'll need to learn how to make boards flat. A 4-in. or 6-in. jointer will do the job if you're willing to rip everything into narrow strips and reglue. (You can reduce boards to uniform thickness with a planer alone, but it won't make them flat.) Flattening, thicknessing, edge joining and gluing enough strips for a 36-in. tabletop is no picnic. And there are times when you just don't want to cut a nice, wide board into strips.



MITCH MANDEL

Learn the techniques of planing by hand, and you'll be able to flatten any board, regardless of size.

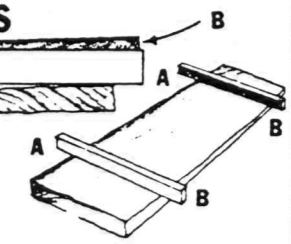
A hand plane allows you to flatten any board, regardless of the board's width, length or thickness. Flattening piles of boards with a hand plane can be strenuous and tedious work. (It was deemed an ideal character-building task for generations of apprentices.) But if you don't have access to a wide jointer, you have no choice. Even if you do, it's useful to know how to flatten boards by hand. If you understand the hand technique, you'll use your machines more skillfully. And when you get a special, wide board, you'll be able to work with it intact.

Tools

You don't have to spend a lot of money for machine tools to flatten and thickness boards. All you need are a sharp hand plane and a workbench, a pair of winding sticks—two straight sticks that gauge the twist of a board—and a marking gauge.

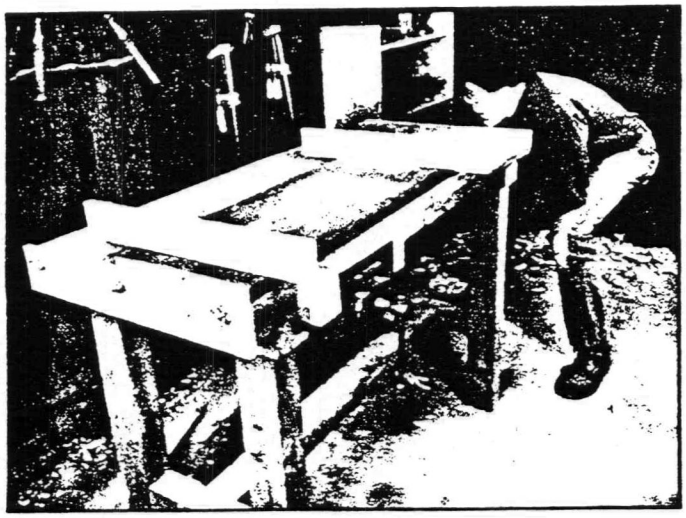
I do all my hand planing with an old Stanley 07 jointer plane. Its 22-in. long sole bridges high spots on a board, instead of riding up and down on them as a shorter plane would. It's heavy, so I don't have to bear down to get the job done. The only drawback is its narrow throat. Because I use this one plane for everything, I've set the throat for finer work, so when I use it for rough planing, the thicker shavings have a tendency to clog the throat. This just means I have to stop and clean out the shavings a little more often. If you plan to do a lot of rough planing, you could do what the old-timers did, and use a scrub plane with a wide throat and a blade that's slightly rounded across its width. A scrub plane is capable of removing a lot of

FIG. 1: WINDING STICKS



Sight along plane of board so winding sticks align at one end (A), then look across to other end (B) to gauge the amount of twist. Plane until sticks align at both ends.

DRAWINGS BY KARL SHUMAKER



PHOTOS BY SCOTT LANDIS

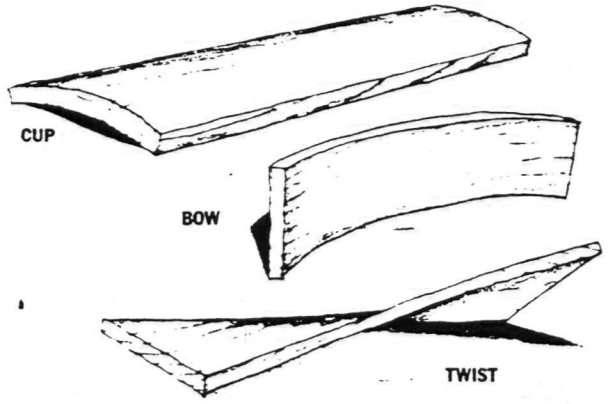
Sight across the top edges of a pair of winding sticks to see if a board is twisted along its length.

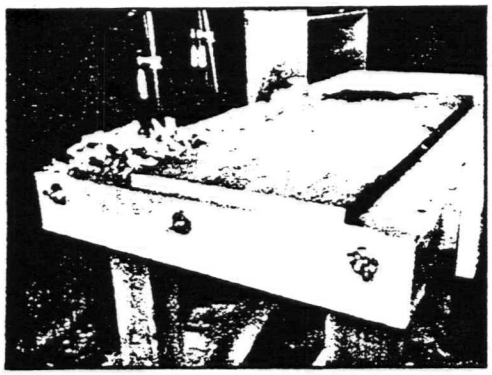
wood quickly. Whatever plane you use, don't worry about the size of the plane you use. Any bench plane (smooth, jack, fore or jointer) will do. It's more important that you feel comfortable with the plane, and keep it sharp.

A workbench fitted with a tail vise and bench dogs is ideal for face planing all but the longest boards. Unfortunately, I don't have one in my current shop, so I've rigged up an adjustable stop on the end of my simple, slab benchtop, as shown in the photo on page 32. I've found that planing into this stop works for most boards, even when planing diagonally across them. A bench dog or two in the holes along the back of the bench helps to hold boards that would otherwise slip around.

It's important that the top of your workbench be flat. A flat benchtop serves as a gauge for determining

FIG. 2: COMMON BOARD AILMENTS



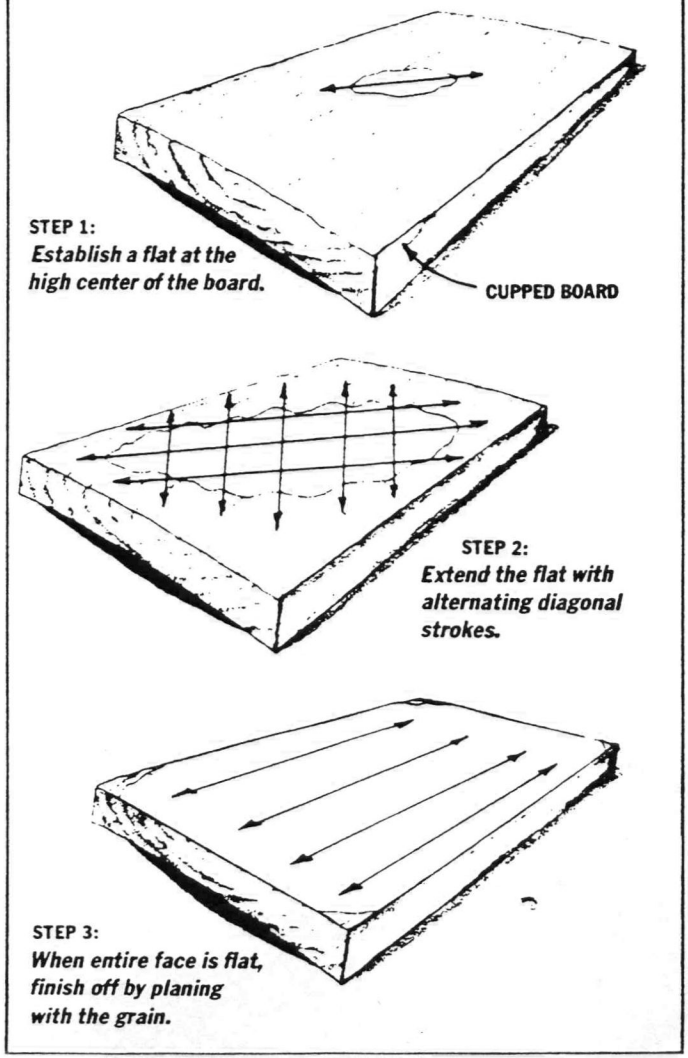


Planing against a simple stop across the end of the bench keeps the board from sliding.

a board's deformities. It's difficult to plane a board flat, particularly a thin one, when it's supported by an undulating surface. Planing your wooden benchtop is an ideal way to practice flattening a surface—it's thick enough so you can keep at it until you get it right.

Winding sticks help you gauge how much a board is twisted along its length. (A twisted board is said to be "in winding" or "wound," hence winding sticks.) They're simply two long, narrow pieces of wood of exactly the same width, as shown in the photo and Fig. 1. They're easier to use if the top edges are two contrasting colors. A handsome mahogany pair I've seen had inlays of ebony on the top edge of one stick and holly on the other. At the other end of the spectrum is the simple pair I recently made. I was in a hurry, so I

FIG. 3: FLATTENING THE CONVEX FACE


STEP 1:
Establish a flat at the high center of the board.
CUPPED BOARD
STEP 2:
Extend the flat with alternating diagonal strokes.
STEP 3:
When entire face is flat, finish off by planing with the grain.

THE PLANE TRUTH

BY KARL SHUMAKER

One day I found myself in the shop facing one of the biggest, prettiest planks of bubinga I'd ever seen. True, it wasn't the most politically correct wood to make into a coffee table, but it was bought before I'd heard of the ozone layer, deforestation, and all the other connections between this board lying on my bench, and the survival of our planet. It had stood for a long time in the stack labled "Someday when I get time." Now I had the time and the idea. But this great expanse of board (1 in. × 20 in. × 66 in.) that was absolutely flat when I had put it away, had taken on annoying curves.

A friend suggested that the only way out was to take it to the machine room and spank it back into shape. I was to rip it into 8-in. widths, run it over the jointer, through the planer, and then edge glue the flat pieces. But how could I disturb that beautiful plane of unbroken grain? That plank *wanted* to stay together. Who was I to get in the way of so noble a desire?

Despite warnings of the hardships of working bubinga, I set expediency aside, rolled up my sleeves and reached for my roughing plane. This board was special. It had waited too long for me to let this experience slip into the dust collector.

I'll grant you, it was work, but sometimes work feels good. I smelled the fragrance of the wood as the shavings formed in heaps around my ankles. The whole process left me intimately acquainted with every square inch of the board. What could have been done in four or five hours with the help of the power company, took ten hours by hand.

In the end, my body had the satisfying feeling that it had been used for a good purpose. My skills were honed just a little bit sharper. But most important, my spirit had been exercised as well. There was a mark on that piece of furniture, wherever it found a home. It still belongs to me as a craftsman—and not to the machines.

ripped two pieces of plywood to the same width and ran a strip of black electrician's tape down the top edge of one. They worked just fine.

You need the marking gauge to scribe the desired thickness on the edges and ends of the board after you've flattened one face. I prefer to use a steel-pointed gauge. The line is always the same width, and I can get very accurate thicknesses by planing to the center of the incised line.

Diagnosing a Board

If a board isn't flat, it will be cupped across the grain, bowed with the grain, or twisted along its length. Frequently, it's all three at once. (See Fig. 2.)

Cupping and bowing are easy to see. Just sight along the end or edge, or check against a straightedge. (The sole of your plane, held on edge, makes a handy straightedge.) Twists are sometimes not so apparent. Even if both ends are flat and both edges straight, a board can still be twisted. The simplest way to check for twist is to place the piece on a flat surface (your benchtop or tablesaw) and push gently on diagonal corners. If it rocks, it's twisted. Mark the diagonal pair of high corners so you can plane them off.

Winding sticks come in handy when you need to check a large board that won't fit on your flat benchtop. Place a stick across the grain at each end of the board, then kneel, and sight across the upper edges of the winding sticks, as shown in the photo. If they're out of line, the board is twisted. The misalignment is often very slight (Fig. 2 shows an extreme case), so you'll need to do some careful squinting.

Remedies

You'll save yourself a lot of elbow grease and no small amount of wood if you lay out and cut the stock roughly to the length and width you need *before* you plane. Why flatten a cupped 12-in. wide board if what you need is two 6-in. wide pieces?

FIG. 4: FLATTENING THE CONCAVE FACE

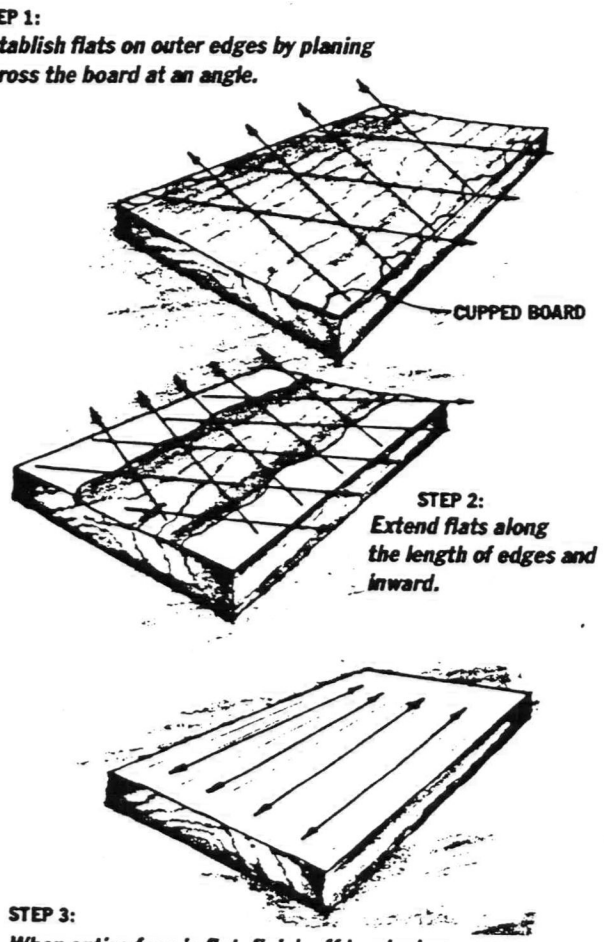
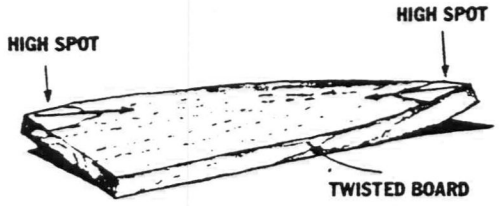
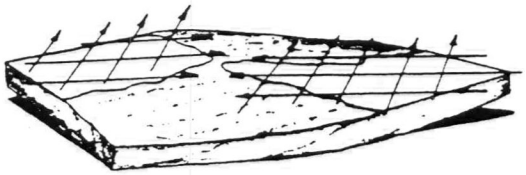

STEP 1:
Establish flats on outer edges by planing across the board at an angle.
CUPPED BOARD
STEP 2:
Extend flats along the length of edges and inward.
STEP 3:
When entire face is flat, finish off by planing with the grain.

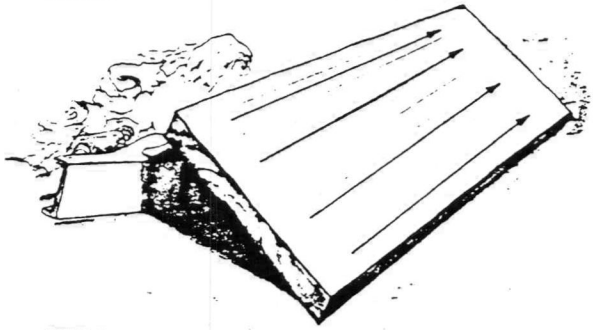
FIG. 5: FLATTENING A TWISTED FACE



STEP 1:
Establish flats on two high corners of board.

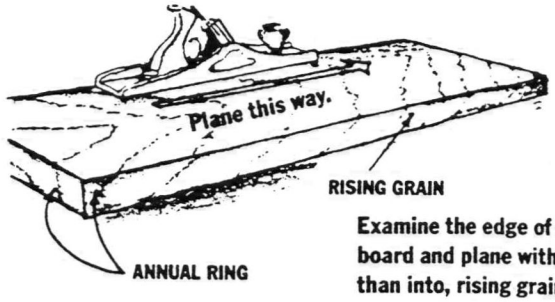


STEP 2:
Extend flats in from opposite corners toward center.



STEP 3:
When entire face is flat, finish off by planing with the grain.

FIG. 6: PLANING WITH THE GRAIN



Examine the edge of the board and plane with, rather than into, rising grain.

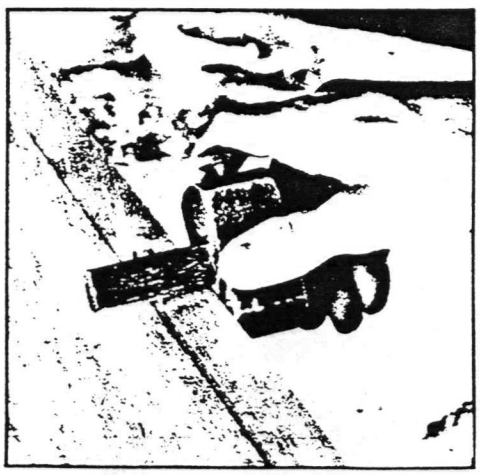
I prefer to start by planing the concave face of a cupped or bowed board. It can be difficult to keep the plane from following a convex curvature. (However, if a badly cupped or bowed board rocks too much while I'm planing its concave face, I'll plane the opposite, convex face first.) With twisted boards the same logic applies—span high spots rather than rock on ridges. However, it's often a tossup as to which face will be easier to plane.

Correcting cupped, bowed or twisted boards is a matter of planing off the high spots. Unfortunately, this is easier to say than to do. The trick, if there is one, is to try to plane off the least amount of wood. If you're planing the convex face, establish a flat surface, and extend it equally in all directions until you reach the low spots. For concave faces this means removing equal amounts of wood from opposing high spots. (See Fig. 4.) A good example of this is boards with just one defect—such as being cupped. Twisted boards are a little more complicated than cupped or bowed boards, but the remedy is the same—remove equal amounts from diagonally opposed high spots, as shown in Fig. 5. Most boards are cupped *and* bowed *and* twisted, so you'll most often need to feel your way along, checking your progress frequently with a straightedge or by eye and adjusting your tactics accordingly. Because you cover much of the surface of a board when correcting for a twist, you can usually take care of the cup or bow as you plane out the twist.

Whatever the defect I'm correcting, I make most of the strokes diagonally across the board, in from both edges. I concentrate on the high spots at first. As the face gets flatter, I cover more of it. The final strokes are along the length of the board, covering its entire surface. Even when I'm using diagonal strokes, I make an effort to plane with the grain wherever possible. The quickest way to determine the direction of the grain is by planing—if you're going against the grain, you'll usually feel, hear and see it. A less nerve-wracking method of determining grain direction is to examine the annual rings along the edge of the board, as shown in Fig. 6.

Though you often want to remove a lot of wood quickly when face planing, thicker shavings mean harder work. The position of the chip breaker on the

Rough plane diagonally across the board. Plane in from the edge where possible rather than off the edge to minimize tear-out.



To reduce a board's thickness, scribe the desired thickness around the edge with a marking gauge, working from the face you've already flattened. Then plane to the line.

HOW TO PUSH A PLANE

Use your entire body when you plane, not just your arms. Control the plane with your hands and wrists.

Shift your weight as the stroke progresses, bringing your legs and back into play.

There's no getting around it. Hand planing a stack of boards (even a short stack) is hard work. But it needn't be back-breaking work. You can plane comfortably for a long time if your bench is the right height and you plane rhythmically, using your whole body to push the plane.

If your bench is too low, you'll get a sore back from bending over it. If it's too high, you'll get sore arms, because they'll have to do all the work. The best rule of thumb I've heard for establishing bench height comes from Frank Klausz, an accomplished cabinetmaker in New Jersey. Frank, who does a lot of hand work at the bench, says that when you stand next to your bench with your arms at your sides and your palms parallel to the floor, the benchtop should just touch your palms. My bench is about 1 in. higher than this, which makes cutting joints in the vise easier, but it's just a little too high for sustained planing.

Like many other strenuous activities, planing is a lot easier when you get into a rhythm. When I'm in the swing of it, I rock back and forth on my heels and toes as my weight shifts from the beginning to the end of the stroke and back again. My hands and wrists hold and guide the plane; my legs, back and arms provide the force.

At the beginning of each stroke, overcome the tendency to let the unsupported rear end of the sole drop by applying pressure with your leading hand on the front of the plane. Likewise, don't let the front of the plane drop at the end of the stroke. As you work your way down a long board, move your body, too, rather than extend your arms farther and farther.

Finally, keep your plane in good working order. A little candle wax rubbed on the sole cuts friction noticeably. And take the time to sharpen the plane iron when it begins to lose its edge, not after the edge is long gone. It's amazing how much less work it is to plane with a sharp tool than with a dull one.—*R.H.*

plane iron is one limit to the depth-of-cut. When rough planing, I set the chip breaker back from the cutting edge between $^1/_{32}$ in. and $^1/_{16}$ in., depending on the hardness of the wood. (A scrub plane with a heavy, curved cutting iron takes thicker shavings and needs greater clearance.) I set the iron for a shallow cut and adjust it during the first few strokes to take a comfortable shaving—thick enough to make the job go as quickly as possible, thin enough to make it as easy as possible.

Thicknessing

When you've got one face of a board planed flat, you can use that face as a reference surface to plane the board to the desired thickness and to get the second face flat as well. Planing a board to correct thickness is a much simpler task than flattening its first face, though it may be more strenuous work if there's lots of wood to remove. All you do is scribe the desired thickness on the edges and ends of the board with a marking gauge, and plane to the center of that line. If the first face is flat, the scribe mark will guide you to make the second face flat, too. Even so, a quick check on the second side with a straightedge or flat surface won't hurt.

If I'm working up a lot of boards, I'll flatten and thickness each one in turn, then sharpen the plane and take a few very fine shavings off all the faces to finish the job. With two planes, you can finish plane as you go.

Flattening boards can be frustrating work at first. You'll plane away and then wonder why the blasted thing still rocks when you check it. But as you gain experience, you'll develop a sense of just where to plane, and the boards, rather than your spirits, will get flattened quickly. ▲

Roger Holmes works wood and writes in Woodbury, Connecticut.

From: American Woodworker (July/August 1990). Photocopied with permission.

From: Charles H. Hayward, Woodwork Joints (Sterling, 1979)

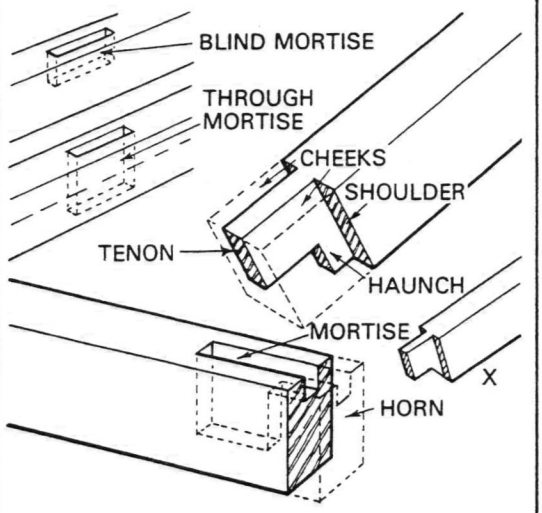


Fig. 1 Parts of the mortise and tenon joint. An alternative secret haunch is shown at X.

Moulded and rebated doors. When a door with a narrow moulding worked around the edge is required the joint at Fig. 2B is the most satisfactory. The moulding is worked in the solid and forms a rebate in which the panel fits. See also p. 43.

It will be seen that the moulding is mitred at the corners. In the stile it is entirely cut away at the joint, and, since the quirk of the moulding is level with the rebate, a level surface is formed. This enables the shoulders of the rail to be level. However, see special note on making barred doors on page 43. It should be noted that when marking out the length of the shoulders the calculation is taken from the rebate, or quirk of the moulding, not the outer edge of the latter. Thus if the over-all width of the door is to be 305mm. (12in.) and the stiles are 40mm. (1⅝in.) wide with a 6mm. (¼in.) moulding worked along them, the shoulder size is 237mm. (9in.), as shown in Fig. 3C. When the door is extra large it is desirable to allow a haunch.

Sometimes a door consists of a plywood or hardboard panel glued to the face of a plain squared-edged frame as in Fig 3D. The simple joint at Fig.

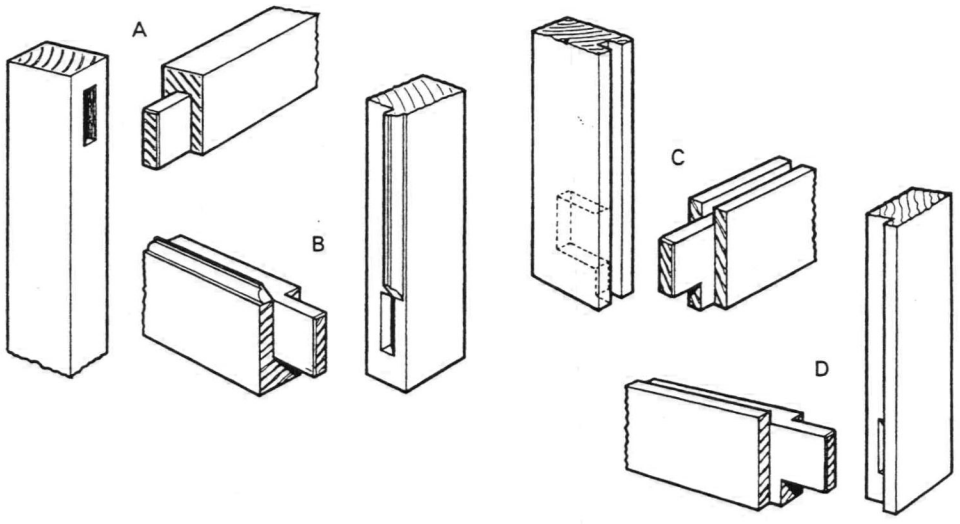
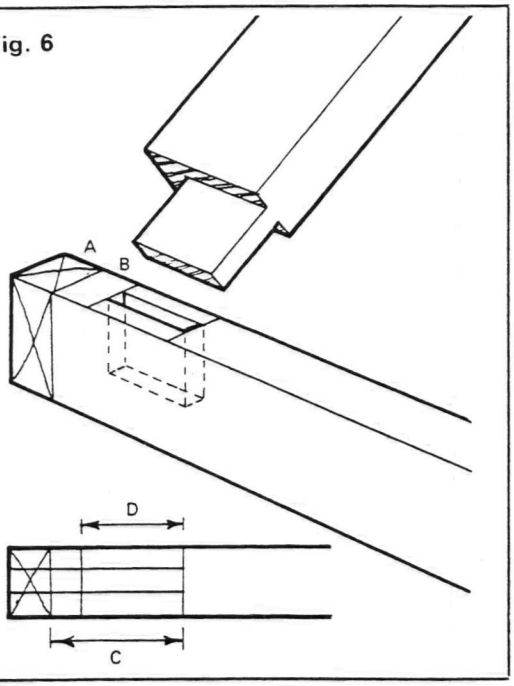
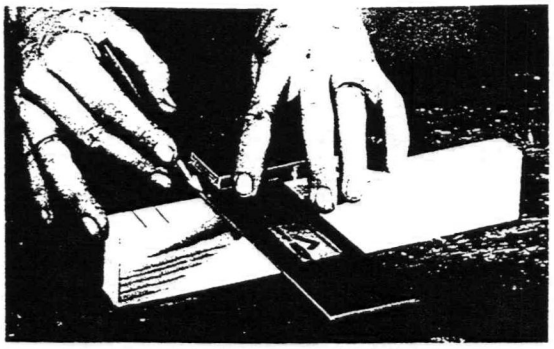
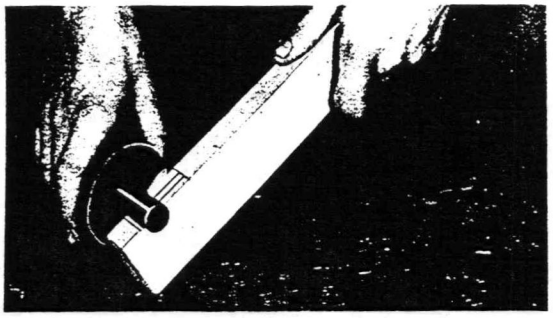


Fig. 2 Mortise and tenon joints used in making doors: A simple mortise and tenon for square-edged framework; B framework with moulding worked in the solid and mitred; C the grooved-in panel necessitates this haunched joint; D square-edged framework with rebated-in panel. In good quality work joints at A,B, and D would have a haunch.

Fig. 6







Cutting the Simple Mortise-and-Tenon

This (Fig. 6) is used largely in furniture-making for doors and frames, etc. The tenon is of the stub type, that is, it does not pass right through. It is set in at one edge, as otherwise it would show at the edge. The extent of this set-in is just a matter of judgment; the more it is set in the more the tenon is cut away, but if it is insufficient the strength at the ends of the rail is reduced. A haunch (see Fig. 1) could be cut, but is frequently omitted.

The illustrations, Fig. 7–16, show the procedure for cutting one joint. If more had to be cut, such as when making, say a door framework, the marking out of all would be carried out in one operation by cramping the opposite parts together and squaring right across. They are then separated and the marks squared round the individual parts as required. This is not only quicker, but it ensures the opposite parts being of exactly the same size.

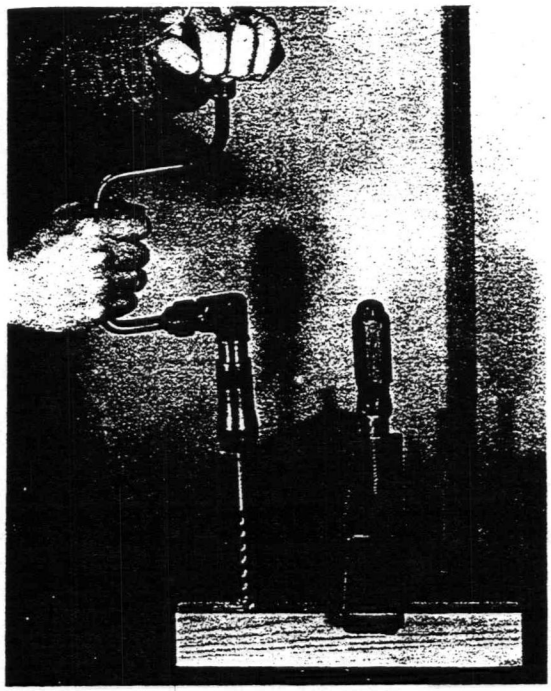
Fig. 6 Simple mortise and tenon joint: A horn; B set-in of tenons; C rail width; D mortise length. In good work a haunch is cut at the set-in B of the tenon.

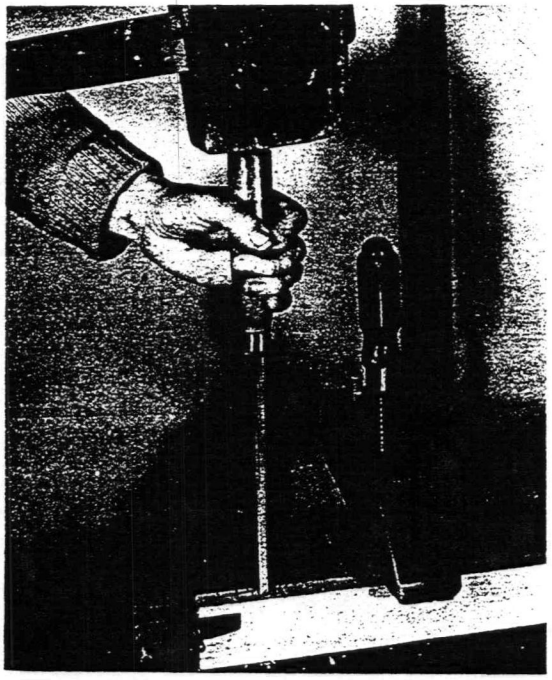
Fig. 7 Squaring mortise position (above right).

Fig. 8 Gauging the mortise (below right).

The tenon should be about one-third the thickness of the wood being jointed, and it is a case of selecting the chisel nearest to this size and working to this. Thus for 18mm. ($\frac{3}{4}$in.) wood the 6mm. ($\frac{1}{4}$in.) chisel is used; for 22mm. ($\frac{7}{8}$in.) stuff the 8mm. ($\frac{5}{16}$in.) size is advisable; for 25mm. (1in.) wood the 8mm. ($\frac{5}{16}$in.) chisel is better; and for 28mm. ($1\frac{1}{8}$in) timber a 9mm. ($\frac{3}{8}$in) chisel is preferable.

Mortising. To mark the mortise, square across the edge the over-all rail width and also the mortise length as in Fig. 7. It is as well to allow 12mm. ($\frac{1}{2}$in.) to 18mm. ($\frac{3}{4}$in.) waste at the end, as otherwise the wood is liable to split when the mortise is chopped. Furthermore, it provides ample trimming allowance. It is known as a horn and is shown





in Fig. 6A. Set the pins of the mortise gauge to the chisel width, and adjust the fence of the gauge so that the points are as near as possible central on the wood. Mark the mortise, working the gauge from the face side (see Fig. 8).

Fix the wood to the bench with a cramp, as in Fig. 9, and, using a twist bit slightly smaller than the chisel size, bore away as much of the waste as you conveniently can. Note that you should stand at the end of the wood, as it is easy to judge whether the brace leans to the right or left, but it is more difficult to judge whether it leans away from or towards you. Count the turns of the brace so that all holes are of the same depth, or use a depth gauge. It is advisable to put a thumbscrew at the end when chopping with the chisel as it lessens any liability of the wood splitting.

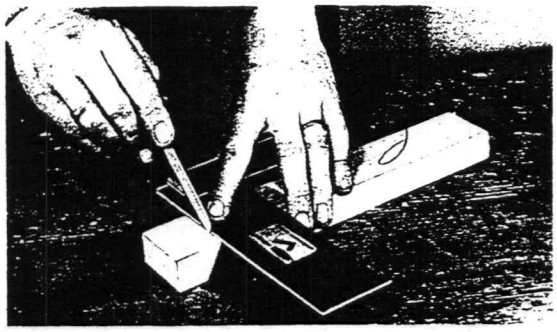
Chop down with chisel and mallet. Start at about the centre, make a slight cut, then work towards one end, gradually deepening the cuts. Reverse the chisel and work the opposite way. Clear away the waste with a slightly smaller chisel. The chisel will have to be levered over to clear the waste, and, as this is bound to burr over the edge of the mortise, the chopping should be stopped about 1–2mm. ($\frac{1}{16}$in.) short of the line. When the waste has been cleared away a final cut can be made right on the line (Fig. 10).

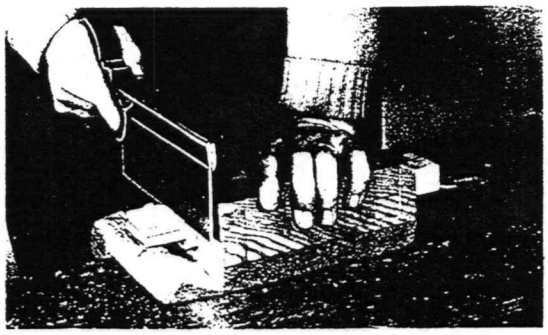
Tenoning. Use a chisel or knife to mark the shoulders of the tenons. Cramp the rails together and square the lines across the edges of both. After separating the rails the marks are squared round both, using the butt of the square from the face side or face edge in every case (see Fig. 11). Hold the work in the vice at about 45deg. leaning away from you, as in Fig. 12, and saw down so that the gauge marks are just left in. Reverse the wood in the vice, this time upright as in Fig. 13, and complete the cut.

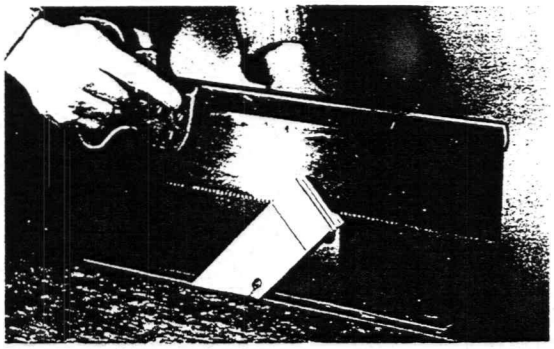
To enable the shoulders to be sawn, chisel a small sloping groove on the waste side of the shoulder line (see p. 20). This will provide a channel in which the saw can run. This not only ensures accuracy but gives a cleaner shoulder. Hold the

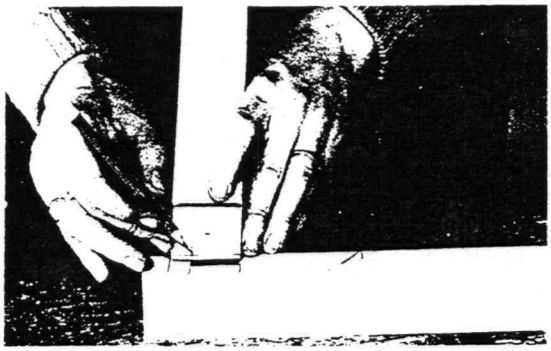
Fig. 9 Boring holes in the mortise (above left).

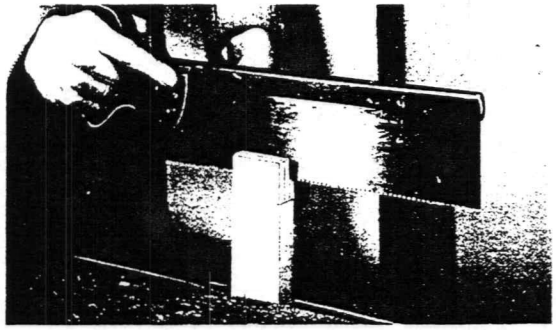
Fig. 10 Chopping the mortise (below left).











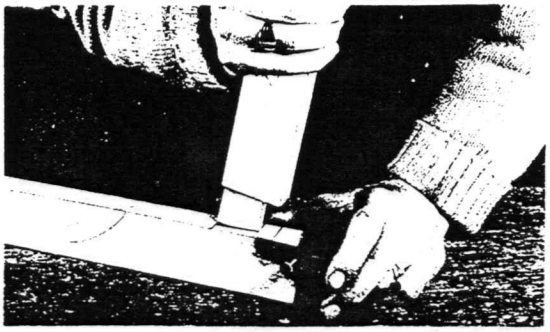


Fig. 11 Squaring shoulders of tenons (top left).

Fig. 12 Sawing the tenon, first stage (centre).

Fig. 13 Second stage sawing tenon (bottom).

Fig. 14 Sawing shoulders of tenon (top right).

Fig. 15 Marking set-in of tenon (centre)

Fig. 16 Fitting tenon to mortise (bottom).

tenon against the mortise and mark the extent of the set-in as in Fig. 15. Saw along the line down to the shoulders and cut away the waste. When several tenons have to be cut it is quicker to gauge and cut the set-in beforehand. With a chisel take off the extreme corners of the tenon. The latter should make a comfortable hand-tight fit. If loose it has little strength; if too tight it is liable to crack the mortise. It is a help if the thumbscrew is left on the end as in Fig. 16.

Faults in the Mortise and Tenon Joint

There are many ways in which the joint can be at fault. A really badly cut tenon is shown in Fig. 29. A common fault is shown in Fig. 30A. The worker has sawn down past the shoulder line when cutting the tenon sides, leaving two unsightly marks.

Another sign of bad cutting is a gap at the outside, as at B. Here the worker has not bothered to mark in properly the set-in of the tenon, and the positioning of his saw is therefore guesswork.

The fault at C is usually found in the work of the man who lacks confidence. He doubts his ability to cut his shoulders square, and rather than risk a joint which will not pull together owing to shoulders which are fuller at the tenon than at the surface, he deliberately undercuts them. The set-in of the tenon at the end is naturally level with the outside, since the saw is held in line with the latter, and the result is the unsightly gap at each side of the tenon.

A loose tenon is obviously useless, but the opposite fault is just as bad and often shows itself in a split at the end of the stile, as at D. Probably the maker, in an endeavour to avoid a loose joint, has gone to the opposite extreme and has tried to force a tight tenon into its mortise. Yet he could have avoided the split by putting a thumbscrew just by the joint. Of course the tenon would have to be trimmed down with the file in any case, but the thumbscrew would resist the split.

A split can also be caused by the mortise being cut too near the end of the wood. It is always advisable to allow at least 12mm. ($\frac{1}{2}$in.) extra length beyond the joint. This waste projection is cut off after assembling. Unevenly cut shoulders are shown at E. Also a haunch which is a poor fit.

The blemish at E is known as a cramp-bound joint and is due to the cramp having been tightened too severely. The shoulder has been so forced against the rail that the substance of the latter has given under the pressure. Only moderate pressure is needed; enough to bring the shoulders well home.

At G either the mortise or the tenon has been cut out of square, causing the rail to be twisted. Again, either the mortise or the tenon may be at fault at H, the two parts not being in alignment. It will be realised that most of these faults are shown in exaggeration to make them obvious.

Concealed faults. So much for visible faults. We now come to those which are hidden. Fortunately

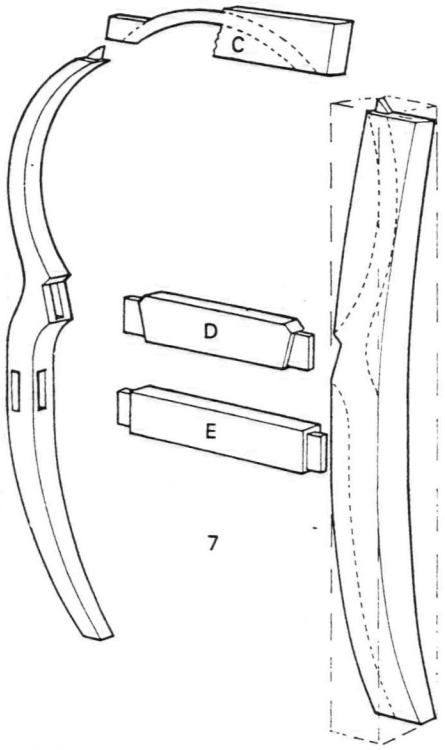


Fig. 28 Parts of the oval-back chair separated, showing the mitred shoulder joint.

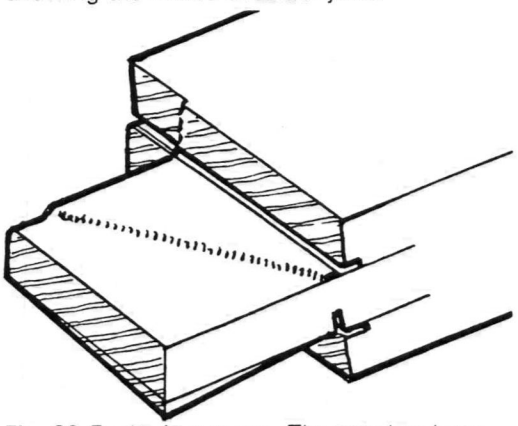


Fig. 29 Faults in a tenon. The saw has been taken beyond the shoulder lines, the tenon sides are out of truth, the gauge lines are taken in too far, shoulders are not square, and the set-in of the tenon cuts the shoulders.

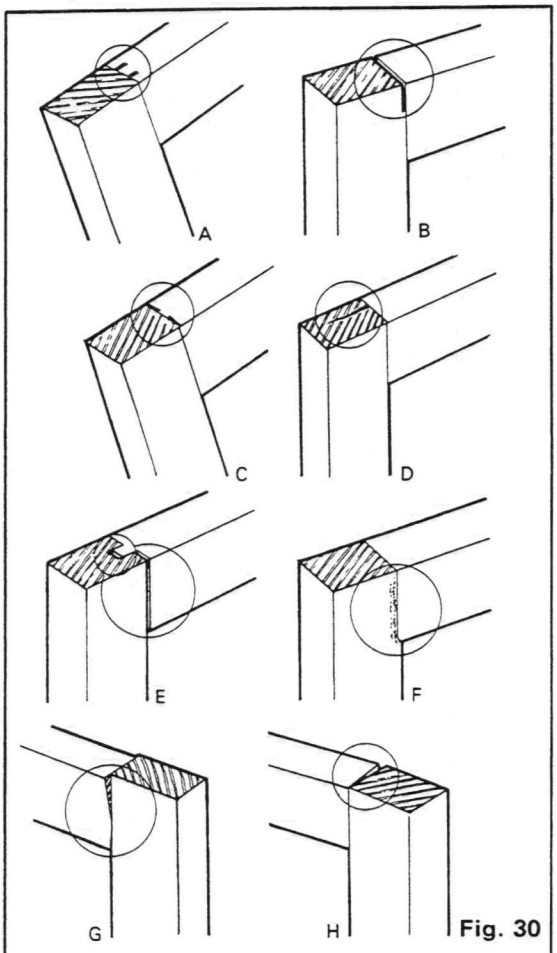


Fig. 30

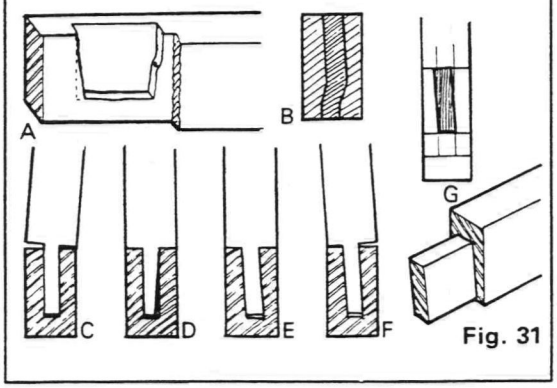


Fig. 31

Fig. 30 Things to avoid in the mortise and tenon joint: **A** tenon sides are sawn beyond shoulder lines; **B** set-in of tenon shows; **C** shoulders are undercut; **D** crack caused by overtight tenon; **E** one shoulder too deep and haunch too short; **F** cramp-board joint; **G** rail twisted; **H** rail not in alignment.

Fig. 31 Faults in the mortise and tenon: **A** mortise unevenly chopped; **B** mortise not straight; **C** tenon not straight; **D** tenon pared away to make the joint true; **E** chance when two faults cancel out each other; **F** mortise out of square; **G** both mortise and tenon twisted.

they mostly come to light when the joint is being fitted, and *have* to be put right. Possibly you have tested the tenon and found that it is just about right in thickness yet it will not go home. Fig. 31A shows a likely cause. The ends of the mortise may either slope inwards or be stepped. The remedy is obvious. If it is a through mortise the sides may not be flat owing to the chisel having been held over at an angle and the result will be that at B.

A sloping tenon or mortise (or both) will cause open shoulders and a winding frame. Fig. 31C is an example. To enable the parts to go together in alignment one side of the tenon will have to be filed down, though this does not make a really sound job because there will be a gap at one side, as at D (it is shown on the opposite side here). Short of making a new part, however, there is no alternative. If both mortise and tenon slope you may be lucky enough to find that they lean the same way and so go together true as at E! You cannot rely on this, and if they are opposed you will have the unfortunate result shown at F.

Winding in a framework can be due to a rather more subtle cause. Either mortise or tenon (or once again both) may be twisted. This is shown in Fig. 31G. Here again the two *may* cancel each other and the joint go together straight, but the reverse is just as likely to happen and the winding will then be increased. Correction with file to the tenon or chisel to the mortise is necessary, but this will of course unavoidably leave a gap.

From: Tage Frid Teaches Woodworking, Book I - Joinery (Fine Woodworking, 1993).

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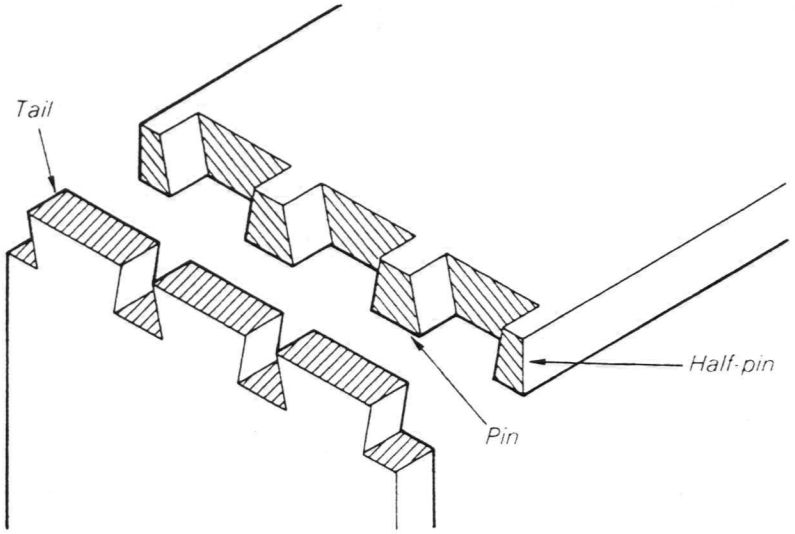
Dovetails

The dovetail has been and still is the mark of fine cabinetmaking. Correctly made, a dovetail is a strong and durable joint. It has a decorative effect and adds a sense of strength to a piece.

There are several types of dovetails. In through dovetails **(1)**, both pieces go completely through each other and the joint is visible on the outside surfaces of both pieces. In half-blind dovetails **(2)**, one piece is joined to about two-thirds the thickness of the corresponding piece, and so is visible on only one outside surface. In full-blind dovetails **(3)**, the pieces are mitered at the edges and the pins and tails stop before the miters so the joint is not visible from the outside of either piece.

Specific tools are required to make hand-cut dovetails. The ease of making the joint and the quality of the finished result depend on the correct use of these tools. Each tool must be sharpened to function correctly.

Once the wood has been milled, the pieces cut to size and the edges squared, marking for the joint begins. The first step in making any dovetail is to scribe the depth of the joint with a marking gauge.



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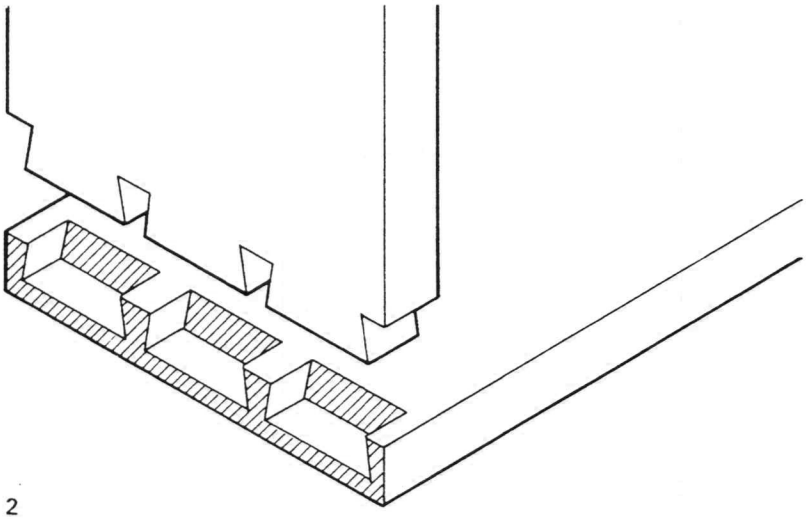

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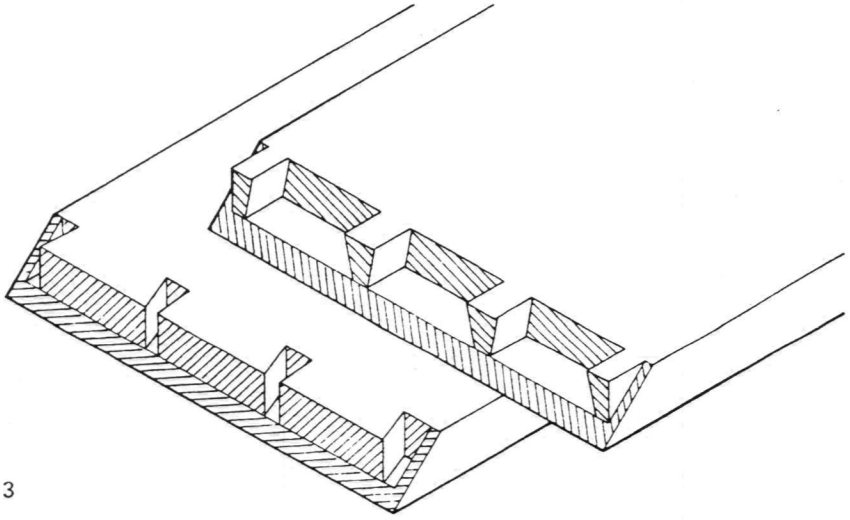

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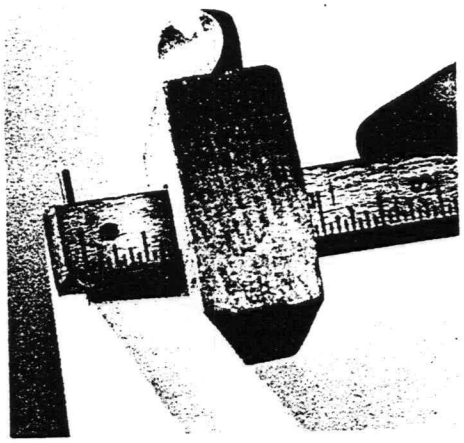
Through Dovetails

For the through dovetail, the full thickness of the wood plus a hair more (about 1/64 in.) has to be set into the marking gauge **(1)**. The extra bit will ensure that the pieces will go all the way through each other **(2)**, and that any excess will come off the pins and tails. It is much easier to sand off this excess. If the gauge were set too low, the whole side would have to be planed or sanded down.

The angle of the dovetail was arrived at a long time ago through experimentation. The angle is about 80°. If the angle were less the tail might slip out; if the angle were greater the wood on the tail would break. Here **(3)** the angle has been exaggerated to show how the wood breaks off. At the extreme points of both parts of the joint the corners are short grain, which breaks easily.

The easiest way to find the angle is to draw a square line across a piece of wood. Divide the line into six equal parts using a ruler or divider. Mark a point to either side of the line the same distance as one part **(4)**. Connect this base point with the top end of the line **(5)** and you should have a triangle, the hypotenuse of which slopes at the correct angle for any kind of dovetail. This is a one-to-six ratio. The angle can be transferred with a sliding bevel to the end of the piece that is to be joined. A sliding bevel is like a square, but the tongue is movable and can angle and slide.

(6) Two types of sliding bevel are shown here. They're both good.



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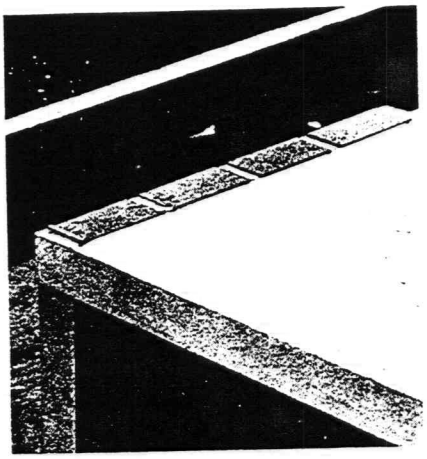

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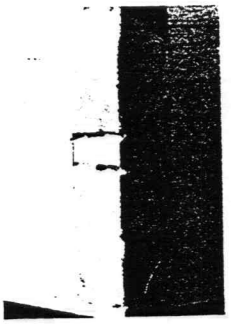

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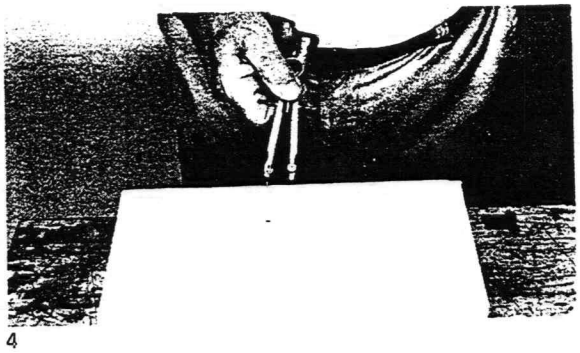

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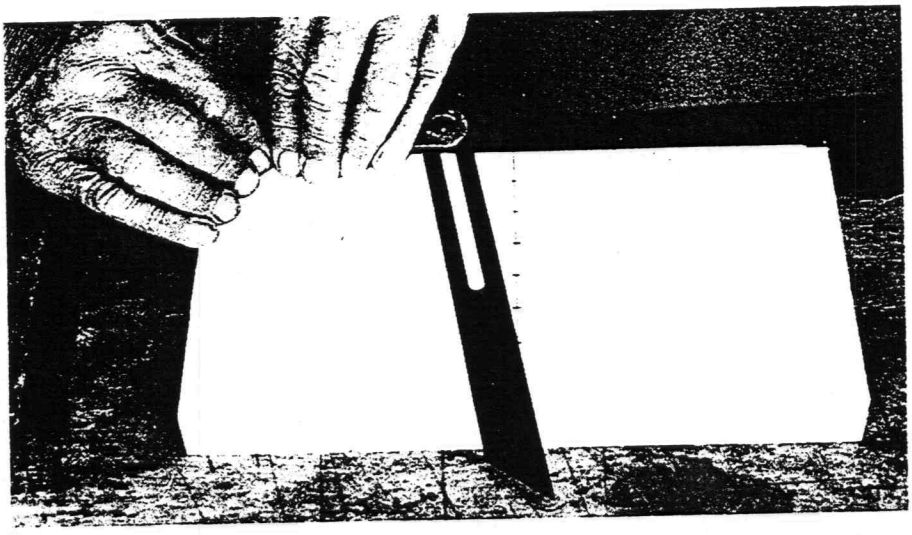

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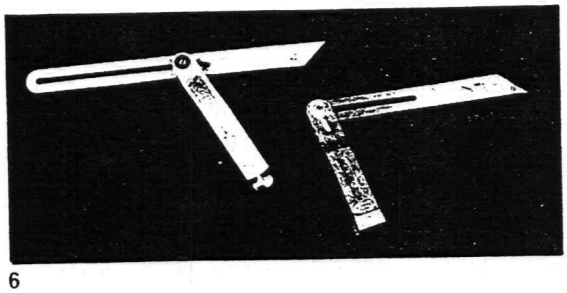

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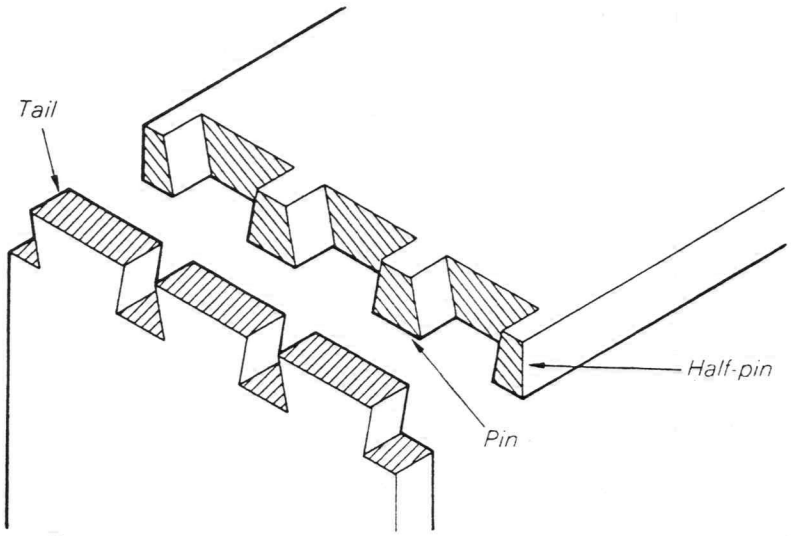

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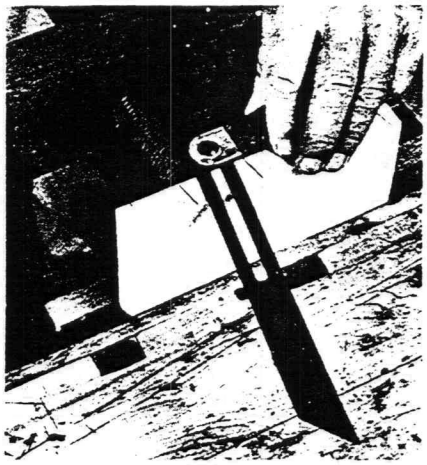

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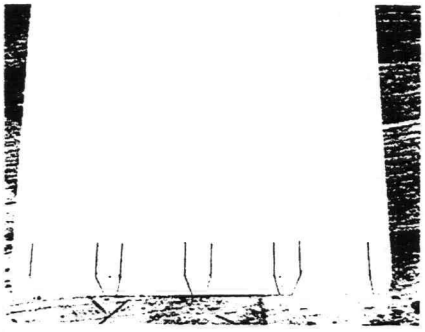

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11

When making a dovetail, start with the pins. The distance between the pins will vary with the width of the wood, but I would never make their centers more than 3 in. apart. When laying out the pins, start with a half pin on each end **(7)** because tails get their strength from being glued to pins, not vice versa. A tail at the end would not be properly anchored because that part is an end-grain joint. A half-pin is called a half-pin because it is angled on only one side, not because of its smaller size.

Divide the space between the pins evenly. The way you lay out the spacing depends a lot on personal taste. If you wish, you can achieve some highly decorative effects.

When you first learn to make dovetails, it is a good idea to lay the pins out using a sliding bevel on the ends **(8)** and a square on the face **(9)**. When you get more proficient, this might not be necessary.

Now the pins are laid out **(10)**. There are different saws to choose from for cutting the dovetails. The only two that I use are the bowsaw and the offset dovetail saw. I use the bowsaw for wood ½ in. or thicker, and the dovetail saw for anything smaller. The bowsaw cuts much faster than any other saw and makes a narrower cut. With any saw, let the saw lie loosely in your hands, and don't apply any pressure. This is especially true when starting the cut. Use your thumb as a guide, keeping the saw to the *waste* side of the line, following or splitting the line **(11)**. Make sure you don't saw below the scribed line depths.

When the pins are cut, the excess is chiseled out with a chisel and mallet. The chisel has to be sharp. Some chisels are manufactured with handles that have rounded ends. I always flatten these out so the mallet won't slide off the end of the handle. The only exception to this is when I am using the chisel as a carving tool, where I would rest the end in the palm of my hand and push with my hand instead of a mallet.

Use a mallet when striking a chisel. If you use a steel hammer, you will flare out the end of a wooden handle. I like lathe-turned mallets **(12)**. They rest in your hand easily and because they are round, they don't have to be used in a specific position.

Once the chisel is sharp, the wood can be removed between the pins. Clean the area of the bench where you will clamp the board to prevent marring the piece. Use a scrap piece of wood between the clamp and the dovetailed piece so that the clamp doesn't leave an impression in the wood. Clamp the wood to the bench, always over a leg so that as you strike the chisel into the piece, the piece will stay firmly seated. If you clamp the piece over the vise, you run the risk of breaking the vise from the force. And the piece will be harder to chisel out, since the vise doesn't provide as much support as a leg.

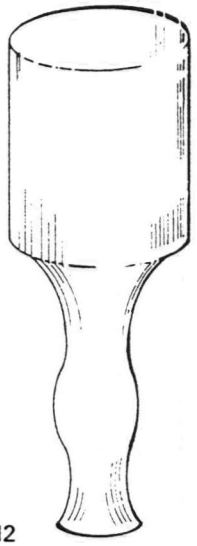
Use a chisel to cut the marking-gauge line deeper **(13)**, so that when you chisel out the waste, the grain won't break behind the line. Then make a *V*-cut at the back of the dovetail for the chisel to rest up against **(14)**. If you didn't do this and you didn't set the chisel in just the right spot on the line, the line would be uneven and gaps would show between the two pieces when they were joined.

The back of the joint is undercut slightly **(15,16)**. The end grain does not provide any glue surface. The object is to get a straight line that will be tight when the joint is together. By undercutting, you ensure that the joint will pull in tight and the line between the boards will be closed.

The flat side of the chisel should be away from you **(17)** when you use the chisel vertically to cut at the back, and should be facing up **(18)** when you cut in from the ends to remove the waste.

Chisel only about halfway down from each side. Don't try and take too much wood with one cut. Be careful not to tear the edges of the pins when their wide side is up. Go partway down and remove the excess before chiseling down again. When you have chiseled about halfway down, turn the piece over and continue the same way **(19,20)**. This helps eliminate the problem of tearing wood out from beyond the joint. Remember to undercut on each side.

Sometimes there are still small pieces of wood in the corners that will have to be cleaned out **(21,22)** for the joint to go together tightly.



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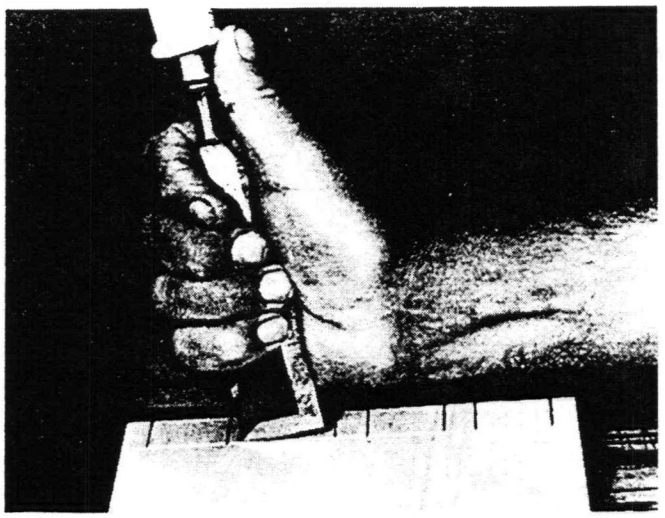

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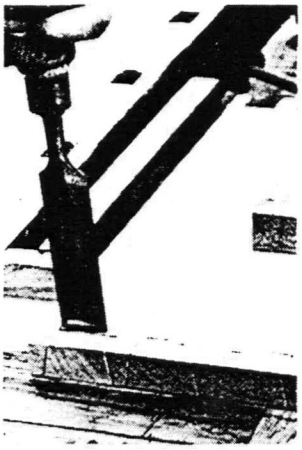

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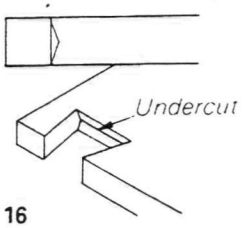

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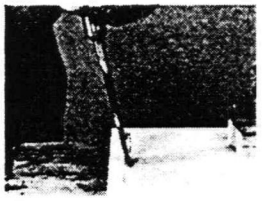

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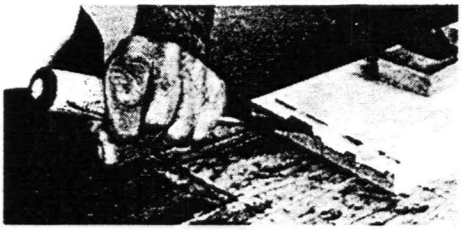

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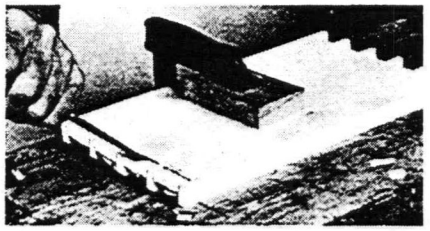

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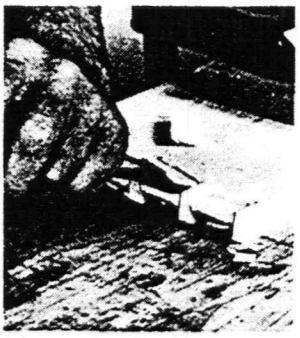

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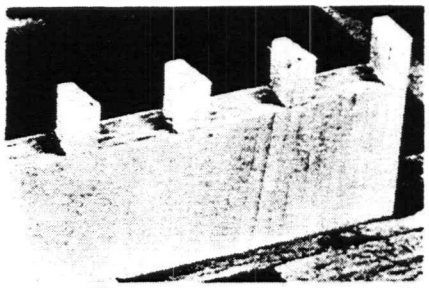

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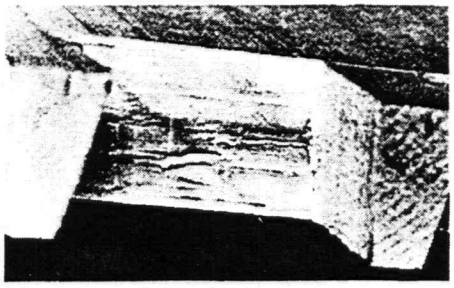

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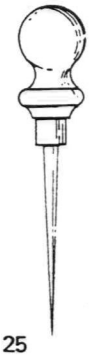

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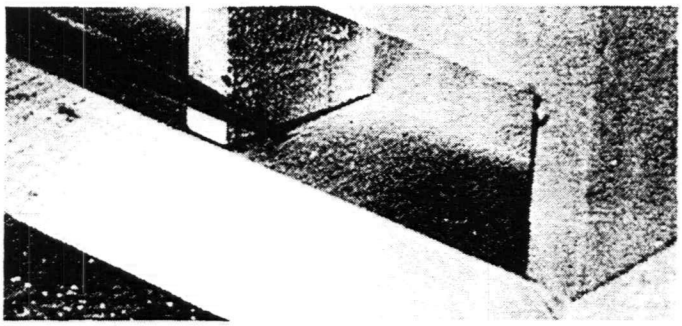

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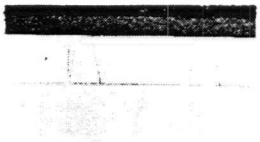

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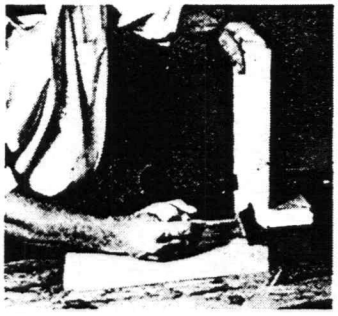

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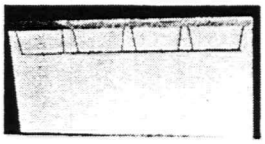

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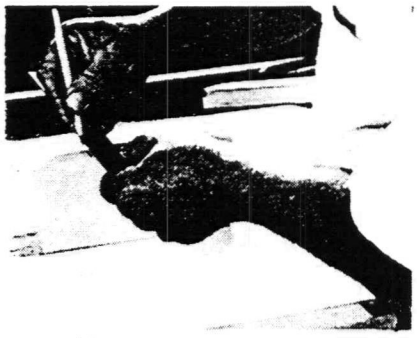

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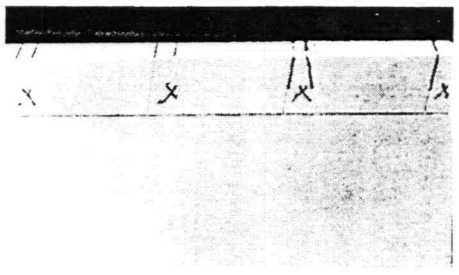

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(23) Here is the cleaned-out corner. Note the undercut **(24)** at the back, or bottom, of the joint.

The reason the pins are made first is that it is easier to follow the tail saw line. If the tails were made first and the pins were scribed onto the end of the wood from the tail, the first sawcut on the end grain would destroy the pin line since end-grain fibers become fuzzy so easily. And we all know how difficult it is to follow a line started on end grain. By making the pins first and scribing the tails from them, we can begin sawing on the face side of the wood, and we have more strokes to try to saw the line accurately.

Instead of buying a scriber, I use a scratch awl **(25)** to scribe with. I like the long, slim awl better, and I don't have to buy another tool. If the end of the awl doesn't come to a smooth, sharp point, the line will move away from the pin. Never use a pencil to transfer lines. It is not accurate enough. (In this book I sometimes use a pencil so the lines will show up in the photographs.) The sharp point of the awl breaks the fibers along the line, making a crisp, clean mark.

Always scribe from the inside of the pieces. If you scribe from the outside, as in the picture **(26)**, the point of the scriber will tend to move away from the pin and follow a grain line instead. Scribing from the inside helps force the scriber up against the pin.

The scribed lines should show clearly. On the second pin from the right in the photograph **(27)** you can see where the scriber followed the grain instead of the pin (when scribed from the outside).

(28) The correct way to scribe is to hold the piece with the pins, putting enough pressure on it so it will not slip. Later, when making half-blind and full-blind dovetails, you'll have to scribe from the inside – you'll have no choice. This picture also shows you what to do if the piece warps. By clamping a board across the width you will straighten it out enough to mark it accurately to the other piece. Once the joint is cut and glued together, the board will stay straight. To prevent marring the surface with clamps, you should always use blocks of wood. I didn't, for clarity.

If the scribed lines are hard to see **(29)** place a piece of white cardboard, or even better, a mirror, in front of the piece **(30)**. The light will be reflected back up and the scribed lines will appear as shadows. This can be a great aid when you begin to saw the tails.

You can also mark the square lines across the end grain using a square **(31)**. This isn't necessary, but will serve as an added guide when you saw the lines.

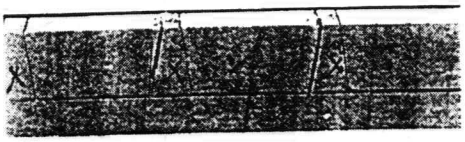
One common mistake people make when first cutting dovetails is that they try to cut the tails a little oversized so they can fit them later by paring them to size with a chisel. This is a bad practice. It is very time-consuming to fit the tails by chiseling and filing them, and it is much easier and faster to learn to saw them correctly in the first place. When you do learn to cut them right and everything fits correctly the first time, you might be surprised. It does take practice. But through this practice, you will gain both self-confidence and experience with the tools, both of which will help making any joint that much easier. The secret to making joints that fit, whether you are making them by hand or machine, is to learn to split the scribed line in half, and always to keep the sawcut to the waste side of the line. The tails can even be cut on a band saw. The principle is the same: Stay to the waste side of the line and both pieces will go together perfectly.

(32) This cut was stopped partway down to show that the thickness of the sawblade is on the waste side (marked with *x*'s) of the line. The cut just splits the line in half.

(33) Here, the sawcut on the right has gone below the scribed line. This cut will show when the joint is together. The cut on the left is on the wrong side of the line.

(34,35) The tails are cleaned out exactly like the pins, but with the opposite sections chiseled out and using a smaller chisel. Undercut except at the ends.

(36) It is advisable to mark the square lines for the cuts that will saw off the end spaces for the half-pins. Then saw out the two pieces **(37)**. Don't undercut here as this edge will be visible. Again, be sure the corners are clean **(38)**.



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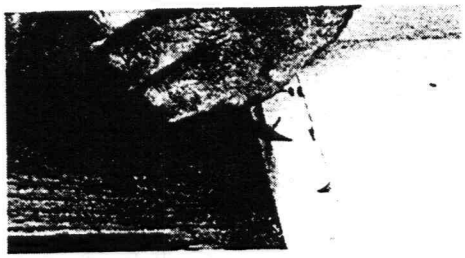

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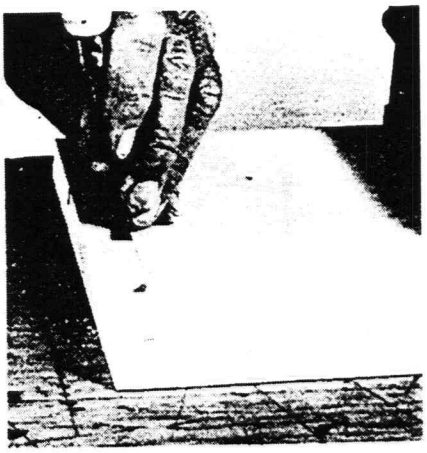

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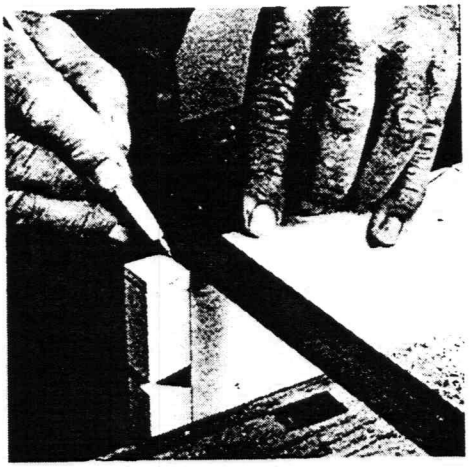

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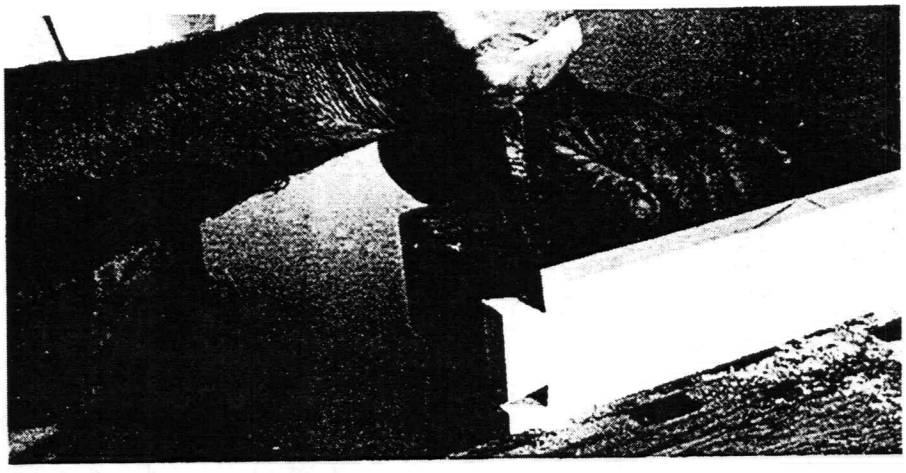

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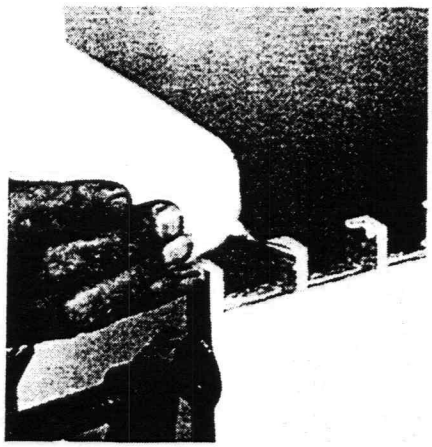

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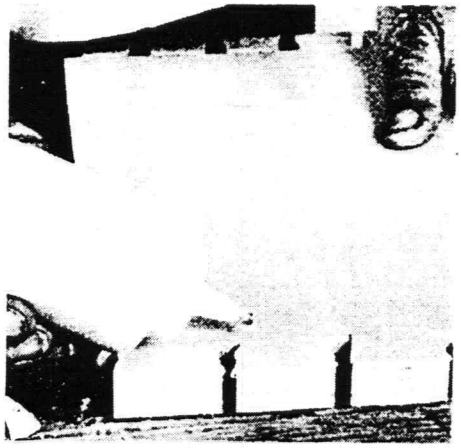

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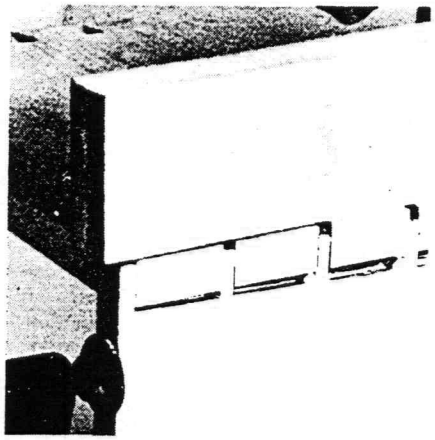

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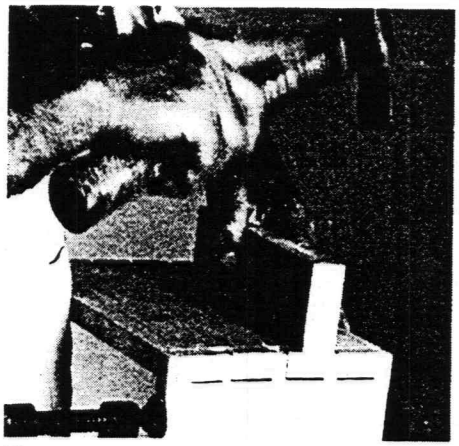

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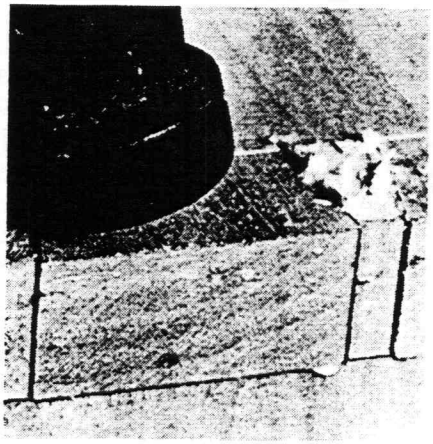

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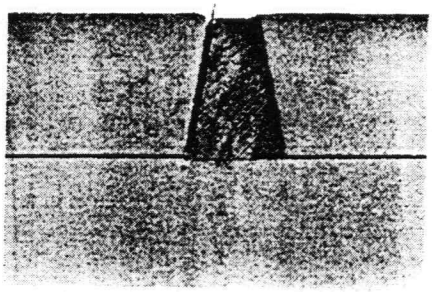
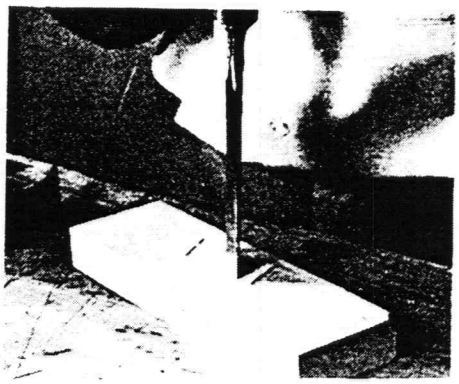




Be sure to sand the inside of the boards before gluing up. Once the pieces are assembled it will be difficult to sand to the inside corners.

Before gluing, you'll want to dry-test your joints, but it is not a good idea to put the joints fully together. Doing so may make the joint sloppy and may even break it. Just check to see if everything fits. Then glue it together and hope. When you glue the pieces, squeeze just a little bit of glue on the top of the pins **(39)** and on the inside edges of the tails **(40)**. As the joint slides together, the glue will be pushed ahead of it. (Of course I would glue up all four sides of a cabinet together at once, not one corner only as in this demonstration.) Use a clamp on the side of the piece with the pins **(41)** to prevent splitting if the joint is too tight.

(42) Use a block of wood to hammer on when joining the pieces. This will prevent splitting and marking up the piece. If the joint fits right, it should not be necessary to use clamps. As you are gluing it up, check to see that the pieces are square.

Whenever I make a dovetail there is no doubt in my mind that it is going to go together. This is because I make the pins first, scribe them carefully to the tails, and make sure to split the line when cutting the tails. If I can split the line, and I usually can, the joint has to go together. It is that simple.

If one of the pins or tails is slightly loose, the end grain can be hit with a steel hammer, just enough to flare out the fibers **(43)**. This should be done when you are gluing up the pieces.

If for some reason a part of the dovetail does not fit at all, saw a cut a little thinner than the thickness of veneer down the line between the pin and the tails **(44,45)**.

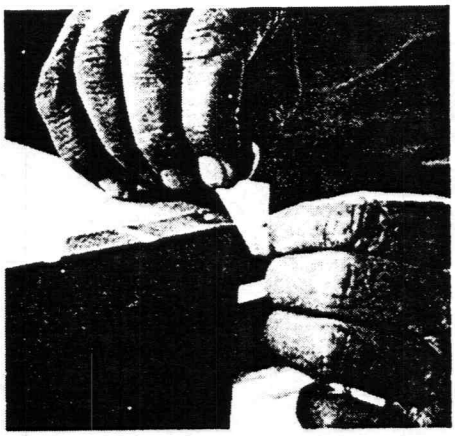
(46) Cut and **(47)** hammer a piece of veneer (preferably against a piece of steel) to compress the grain, or squeeze it in a steel vise to flatten it out. Cut the piece of veneer at 45° so that the grain will run in the same direction as the pins.

When applying the glue, rub it into the sawcut using your finger to force it in deep. Don't put glue on the veneer or it will swell up before it is inserted. When inserted **(48)**, the veneer will pick up some moisture from the glue and will expand to fit the slot perfectly. Be sure to choose a piece of veneer – or if you make your own, a piece of wood – that has the same color as the pin.

When the glue is dry, the veneers sawn off **(49)**, and the piece is sanded, no one will see the patch. The marked areas **(50)** show where the veneer was inserted and sanded off. You notice it only if it is brought to your attention. Sometimes, with a perfect color match, it is impossible to see.

If I am making several sets of dovetails, I stack up all the pieces for the pins and chisel them all out at once **(51,52)**, scribe each joint to its corresponding piece and then stack up all the tails and chisel them all at once. This saves considerable time.

47



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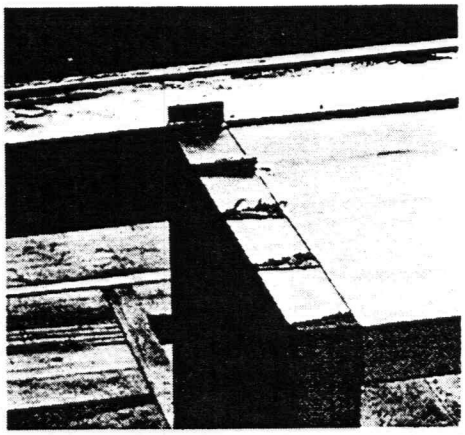

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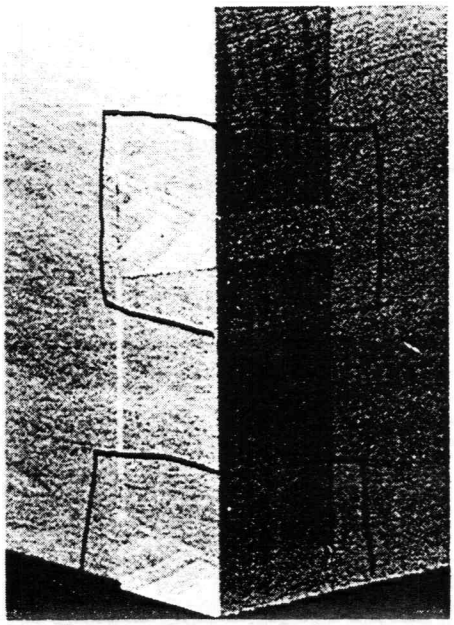

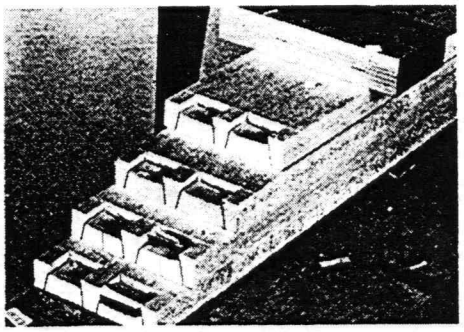

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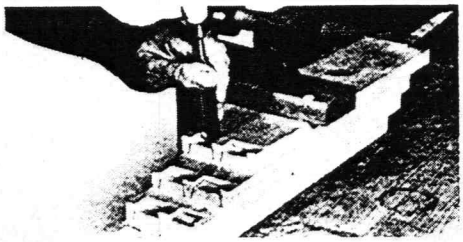

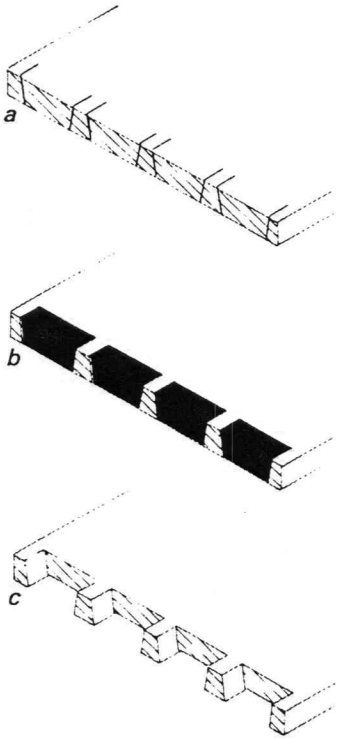

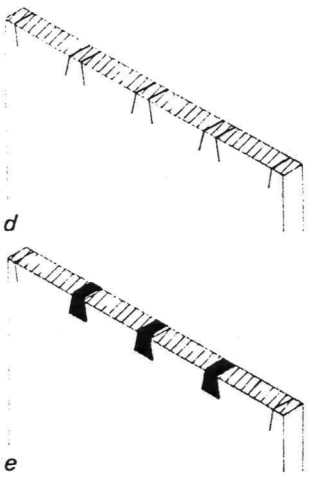

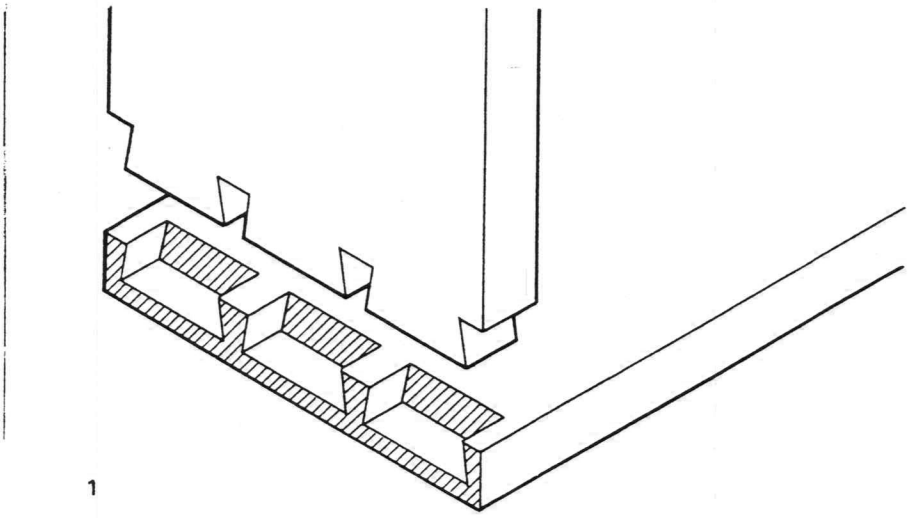

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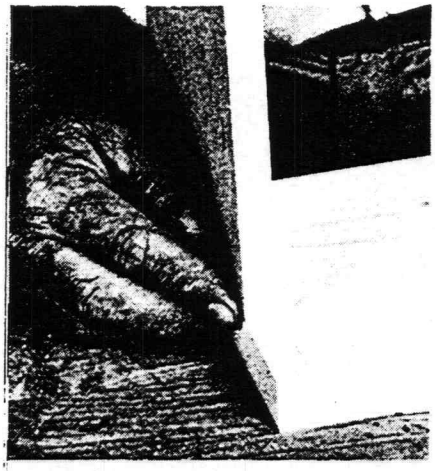

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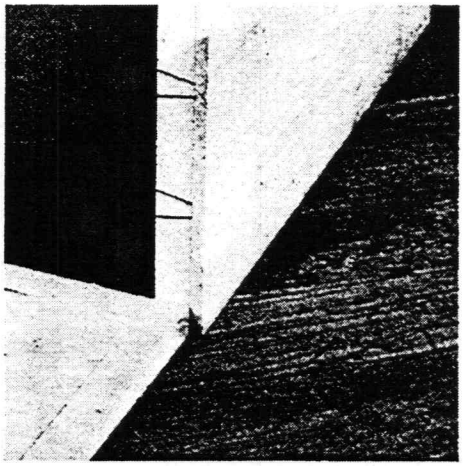

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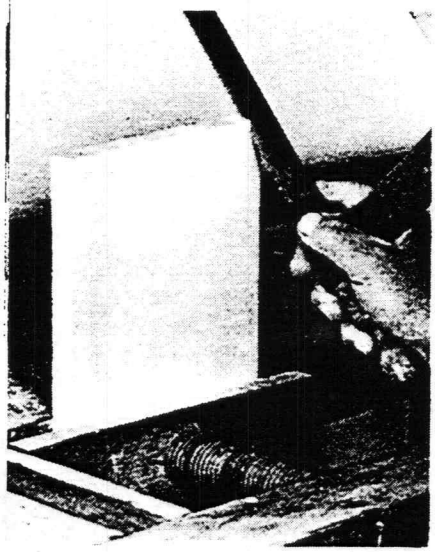

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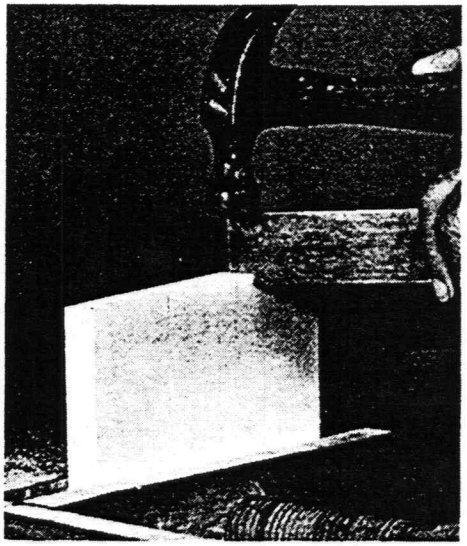

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Half-Blind Dovetails

A half-blind dovetail **(1)** is used primarily where you want only one side of the joint to show. It is often used to join drawer fronts to sides. In that case, you usually don't want to see the joint on the front of the drawer, but a nicely made dovetail would look fine on the drawer side. With drawers, the sides are usually thinner than the front. Half-blind dovetails can be used for pieces of different thicknesses or for pieces of the same thickness.

Here, pieces of different thickness are being joined. If this were a drawer the pins would be in the thicker piece (the drawer front), and the tails in the thinner piece (the side). The side must be flush with the end of the front. Using an awl, mark the full thickness of the side onto the front piece **(2)**, then scribe with a marking gauge. The depth of the pin should be about two-thirds the thickness of the front So set the marking gauge to that depth and mark the ends of the front, and with the same setting, mark the sides. Then lay out the pins exactly as when making through dovetails **(3)**.

To saw out the pins, hold the saw at an angle **(4)** so that it cuts only between the two scribed lines on the edge and front.

An old scraper blade or sawblade completes the cut. Make sure the scraper isn't sharp so it doesn't split the wood. Hammer the blade down **(5)** until it reaches the bottom corner of the cut. Pop it out **(6)** by hitting the underside upwards with the hammer.

(7) Chisel out the excess the same way as in a through dovetail (see p. 67), but of course, you can work from only one side. Chisel down to the marked line on the end of the front piece.

(8) Clean the rest of the wood out, and again, undercut.

(9) Be sure the corners are cleaned out.

6

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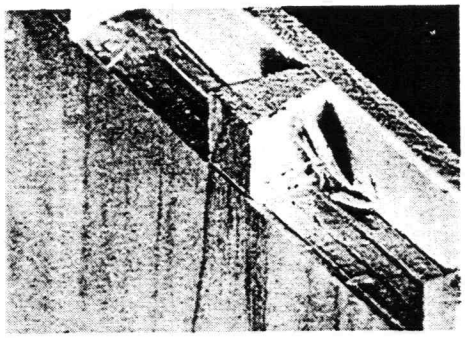

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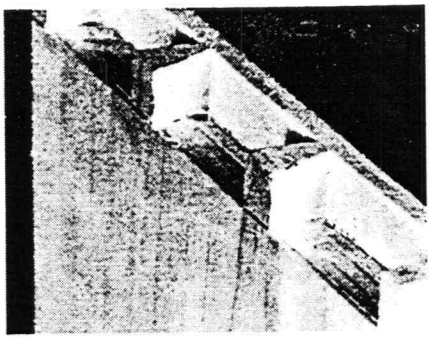

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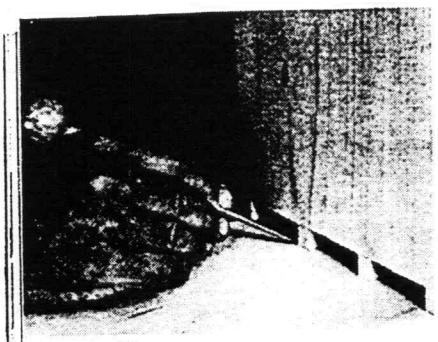

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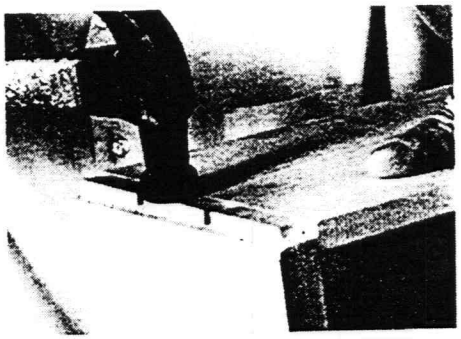

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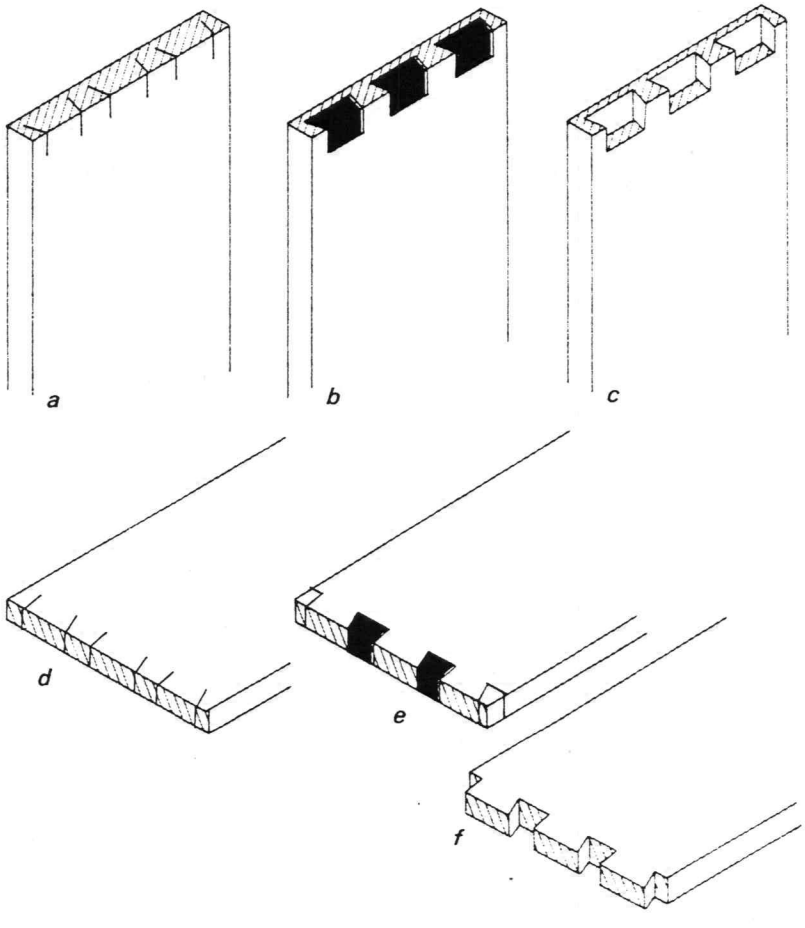


(10) To lay out the tails, scribe them from the pins, making sure the board with the pins is offset to make the inside edge flush with the marking-gauge line since these are not through dovetails. Cut and chisel the tails the same way as in through dovetails.

(11) When the joint is completed, tap it together lightly to check the fit. Use a block of wood for better protection.

(12) Don't work it all the way down until you are gluing it up. □

FINDING BOARD FEET:
How To Determine Lumber Requirements For Your Projects

by David E. Donnelly

Playing with a pocket calculator to compute your lumber requirements may not be your favorite way to spend a Saturday afternoon. But it can save you a lot of money and needless aggravation when you know your precise needs.

A board foot is the common unit of measure used to calculate lumber volume. There are two reasons why it is useful to know how to measure board footage. First, you can prepare a bill of materials for your projects to determine exactly how much lumber you need, and second, you can estimate your costs since solid lumber is priced by the board foot.

A board foot takes into consideration the thickness of a piece of wood, as well as its length and width. The total volume of one board foot is 144 cubic inches. This is the same as a piece 1" thick x 12" wide x 12" long (1" x 12" x 12") or its equivalent (See Fig. 1).

Like many things in life, there's a catch involved in these measurements. Very often, you pay for "x" number of board feet, but receive much less. It's because of the method by which thickness is measured . The thickness is determined **before** the wood is dried and surfaced.

If you order wood that is surfaced S2S (surfaced two sides) and it measures ¾" thick, it's still considered to be 1" thick for the purpose of measuring board footage. The reason is because the wood was cut 1" thick before it was surfaced. So in a sense, you're paying for both the wood you receive and the waste involved in surfacing it.

Here's the formula for calculating board footage:

$$BF = \frac{PCS \times T \times W \times L}{144}$$

BF = Board Footage
PCS = Number of Pieces
T = Thickness
W = Width
L = Length
(All measurements are in inches, including length)

Your board footage needs for a specific project are really based upon your bill of materials, or overall lumber needs. For this reason, we've devised a combined **Bill of Materials and Board Foot Calculator** form (See Fig. 2) that simplifies the math involved. Simply put your figures in the blank spaces provided and perform the necessary calculations with a basic pocket calculator. There is also a line to estimate your total lumber cost after you know your board footage requirements.

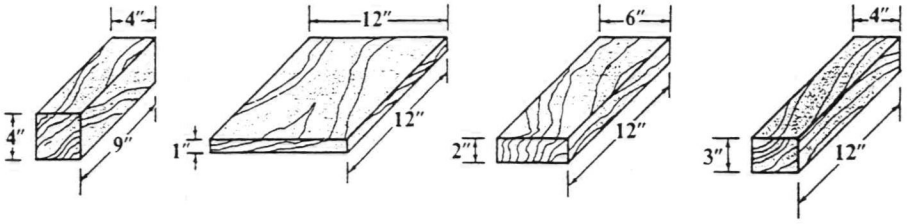
Use a separate copy of the form for each different type of wood you need, as well as each different thickness and type of surface.

Lumber thickness is usually measured in quarter inches, such as 4/4, 5/4, 8/4, 10/4, and so on. Your board foot measurements will be simplified if you change these fractions to decimals when making your calculations. The above fractions would become 1, 1.25, 2 and 2.5. The form shows how to make these changes. Remember to enter the *rough* thickness, not the *surfaced* thickness. There are several different methods used to measure the quantity of lumber, depending on the form in which its available . . . it's not always by the board foot. Board foot measurements are used primarily for solid lumber. Man-made materials such as plywood and particle board are sold by the square foot. Strip lumber, such as molding, trim, and doweling, is sold by the linear foot, or running foot. In these cases, board foot measurements do not apply.

One final word of caution. After calculating your lumber costs, we emphasize that this cost will be "approximate." In fact, it will always be on the low side. Here's the reason. Suppose you figure that you need 5.6 board feet of wood. Round up your number to the nearest whole foot when you order your wood. You now have 6 board feet. But when you place your order, the smallest piece the lumberyard has is 8 board feet. You'll have to buy the full 8 board feet because they won't cut the board to your specifications and "eat" the waste. By the time you've figured in every piece you need for a large furniture project, that can add up to quite a bit of extra wood. By carefully selecting your pieces and sizes, this excess cost can be minimized.

ONE BOARD FOOT (144 Cubic Inches)

Fig. 1



BILL OF MATERIALS AND BOARD FOOT CALCULATOR

Fig. 2

Project: _____ Page: _____ of _____

Type of Wood: _____

Rough Thickness: _____ Surface: _____

Name of Part	No. of Pieces PCS	Rough Dimensions (Inches) Thickness* T	Width W	Length L	Compute: Divide Top Number by 144	Board Feet BF
		x	x	x	= / 144	=
		x	x	x	= / 144	=
		x	x	x	= / 144	=
		x	x	x	= / 144	=
		x	x	x	= / 144	=

* Thickness: Convert Fractions to Decimals	
3/4 = .75	8/4 = 2
4/4 = 1	12/4 = 3
5/4 = 1.25	16/4 = 4
6/4 = 1.5	

Add BF Column For Subtotal = _____

20% Waste Factor: _____ (Subtotal) x 1.20 = _____

Round Up To Nearest Foot = _____ ← TOTAL BF

Price: _____ (Total BF) x _____ (Price Per BF) = _____ ← APPROX. PRICE

Project:
Client:
Date:

STOCK LIST

Board Feet

$\frac{L" \times W" \times T"}{144}$

Rough Dimensions

L + 1"

W + 1/2"

T + 1/4"

	ROUGH				FINISH						
NAME	#PCS	L	W	T	#PCS	L	W	T	WOOD	B.F.	NOTES

Total _____

+15-20% _____

TALKING TURKEY IN A LUMBERYARD

By David E. Donnelly

To be a knowledgeable consumer when you purchase wood, you need to talk the vernacular of the lumberyard. We'll describe a few basic categories of terms that are helpful to know and easy to learn. When you converse with the sales people on their terms, they'll recognize you as a discriminating buyer.

GRADE. This is a quality rating assigned to individual boards. Lumber is graded by visual inspection, a judgment based upon appearance, suitability to end use, and certain pre-established criteria.

Grading provides a useful yardstick in measuring lumber's quality. Higher grades are more expensive, but it's not always necessary to buy the highest quality. For example, you might be able to cut around a defect in a lower grade board.

Here are grades that refer *only* to hardwood; softwood is graded differently.

First and seconds. FAS is premium quality furniture grade and will have the least defects. A board must be at least 6″ x 8′ and yield 85% to 90% **clear** (unblemished) surface on the poorer face.

Select and better. SEL is lower quality than FAS, but is still satisfactory for most furniture products. Minimum board size must be at least 4″ x 6′ and must be 80% to 85% clear on its best face.

No. 1 Common. This grade includes shorter, narrower boards, is less expensive, and will contain a greater number of defects. Minimum sizes are 4″ x 2′ or 3″ x 3′. Boards must be 66% clear on the poorer face.

Grading can be misleading and confusing. Since human judgment is used to make quick decisions, you may frequently find a board marked SEL that looks like it should be FAS. Also, some species cannot qualify for FAS regardless of how clear the boards are because they cannot meet the minimum length or width requirements. For additional information, contact the National Hardwood Lumber Association, P.O. Box 34518, Memphis, Tennessee 38184.

THICKNESS. Lumberyards talk about the thickness of lumber by the quarter inch and express it as a fraction. See "Finding Board Feet" page 37.

SURFACE. When lumber is cut at the mill, it's very rough and must be smoothed (or surfaced) before it can be used for building your project. The more your wood is surfaced when you buy it, the more expensive it is. **Rough (RGH)** wood hasn't had any surfacing done and is the least expensive. However, in order to work with rough lumber, you'll have to do the surfacing yourself with a jointer or planer. If you're more than an occasional woodworker, an investment in these tools can quickly pay off in lumber savings.

Other types of surfaces you may run across are:

S1S, S2S, S3S, S4S, meaning surfaced on one side, surfaced on two sides and so on. In this case, the first two sides refer to the **faces,** or wide sides. The second two sides refer to the edges, or the narrow sides.

S1E or **SL1E.** Surfaced one edge or straight line one edge. In this case, one edge has been joined, with one straight line to place against the fence on your table saw.

Hardwood is also generally sold in **random widths and lengths (RWL).** This is because the lumber is too expensive to waste by cutting down to pre-established standards. For instance, if a board is acceptable as 7″ wide, why waste an inch just to cut it to a standard 6″ width?

If you have a jointer but no planer, you may wish to purchase your lumber S2S and join the edges yourself. If you own a planer and no jointer, SL1E may be your best buy.

It's a good rule of thumb to buy it ¼″ thicker than you need for your final project. This allows ¼″ as a "cushion" for planing and sanding.

DEFECTS. Defects are important to note and may not be reflected in the grading. Grading considers such defects such as knots, but not warping. Some defects can be corrected in joining, planing and sawing.

Knots. These are the most common "defects" in wood. A knot represents a mass of cross-grained fibers caused by a branch or limb at that point. **Sound** or **tight** knots will remain in tact and may add attractive effects to your projects. **Unsound** or **loose** knots may fall out and should be avoided or cut around.

Wane. A bevel on the edge of a board where the bark meets the wood.

Splits and checks. Lengthwise cracks at the end of the board.

Bow. A deviation from a flat plane on the wide face of a board.

Crook. A deviation from a flat plane on the narrow edge of a board.

Twist. A deviation from a flat plane causing a board to spiral from end to end.

Cup. A deviation from a flat plane edge to edge.

VOLUME. Lumber is priced by the foot, but there are two different ways of measuring a foot.

LF or **LIN FT. Linear foot.** Wood such as molding is priced by the linear, or running foot, where thickness and width is not a consideration.

BF or **BD FT. Board foot.** A board foot is one inch thick by 12 inches wide by 12 inches long. (See article "Finding Board Feet" on page 37.)

OTHER TERMS. The following terms are handy to know, but less important when making your purchase.

SEASONING. This refers to how moisture is reduced (Air Dried or Kiln Dried) to control the wood's stability.

CUTTING METHODS. This refers to how the board was cut (Quarter Sawn or Plain Sawn) and is reflected in the pattern of the annular rings (grain).

PRICE. The board foot price for small purchases is very high, relatively speaking. Price breaks come at the hundreds and thousands of board feet. When making small purchases, your first price break comes at 100 board feet, so buy in volume if possible. Perhaps with a friend.

Prices are usually given by a thousand board feet. If you ask a salesman how much a certain grain costs for the types of wood you need and he responds, "Thirteen twenty a thousand," that means $1320 for a thousand board feet. Which is actually $1.32 a board foot.

We hope the explanation of these terms will help make your next trip to the lumberyard a pleasant one.

FUNDAMENTALS OF FINE WOODWORKING

DOVETAILED BOX OUTLINE

I Prepare inside faces of side pieces
- A. Lightly plane to remove mill marks
- B. And/or, card scrape
- C. And/or sand 120 then 220 (use a block-do not dub edges)

II Organize and label parts
- A. Mark inside face and bottom edge of two long sides and two short sides
- B. Mark top face of bottom panel
- C. Mark Bottom face of top panel

III Book out pairs of side pieces
- A. Inside faces together with grooves aligned
- B. Check ends for square and matched lengths
- C. If necessary plane end grain surfaces

IV Mock up box and mark adjacent corners to be dove tailed. Be sure to check for this orientation as you lay out and cut the joints.

V Layout joints
- A. Use marking gauge to transfer thickness of short sides to the long sides for the depth of the pin sockets (approx. 7/16)

NOTE: Only the inside faces should be marked

- B. To leave a 1/8" lap on the outside face, keep the gauge set as before.
- C. Mark end grain surfaces of long sides, referenced from inside face.
- D. Mark short sides on both faces and both edges, referenced from end grain surfaces.
- E. Lay out Pins with pencil lines.
  1. Use drawing to transfer spacing.
  2. Bottom groove must occur in tail space.
  3. Notice that in the drawing the top edge of the short sides aligns with bottom edge of the top groove. This controls the location of the top pin. The short sides are left wide for later trimming.

VI Cut pins
- A. Saw, chop and pare.
- B. Test all surfaces of pins and pin sockets. Pare to correct any defects before next step.

VII Scribe pins to their respective tail locations.
- A. Maintain orientation established in IV
- B. Keep grooves and edges aligned.

VIII Cut tails
- A. Saw cautiously
- B. Chop and pare waste to gauge lines
- C. Pare and test tails for a good fit
- D. After fitting is complete, mark bottom of top groove onto short sides. Plane edges to this line, keeping them square.

IX Prepare bottom panel
- A. Mock up box
  1. Transfer depths of grooves to bottom edges of box. Use square as depth gauge
  2. Tap joints together (or clamp)
  3. Test and/or adjust for equal diagonals.
- B. Test and/or correct size of bottom panel relative to these marks.
  1. It should be close in length. (But somewhat shorter-1/32 to-1/16).
  2. It should be narrower in width by about 3/32-1/8"
- C. Skim plane and/or scrape and/or sand both faces
- D. Referenced from top face, mark thickness of bevelled edge. Use square as pencil-gauge
- E. Referenced from edges, use square to pencil-gauge lines on to bottom face to indicate width of bevel
- F. Plane ends first, testing fit of bevel into a groove. (you will need to take box apart)
- G. Plane long grain bevels last
- H. All four bevels should be able to bottom out in a test groove
- I. Test fit panel into grooves with box dry-clamped
  1. It should be free to move in width (for later expansion and contraction)
  2. It must not be so tight in length, width or thickness of bevel as to interfere with fit of dovetails
- J. Begin finishing of panel.

X Glue up box.
- A. Be sure panel is correctly positioned and not glued into grooves
- B. Clamp as necessary to close joints
- C. Test and adjust for diagonals

NOTE: "Move clamps to be more parallel to the longest diagonal".

- D. Remove squeeze out from inside of box when dry but still rubbery to avoid smears.

XI When dry and cured, level joints and skim outside faces and edges.

XII Prepare top panel
- A. Skim and sand faces
- B. Length is same as box, but leave a little long to adjust to box later, if necessary
- C. Width is narrower than distance between grooves (3/32-1/8")
- D. Pencil gauge thickness and width of bevel onto edges, as before
- E. Plane and test fit into box
- F. Scribe ends to box, if necessary so it is flush at both ends
- G. Mark and cut finger-pull.

XIII Finish sand box and lid.

XIV Finish box and lid.

wn
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Thomas S. McAndrews
401 846 6811
Newport RI

NORTH·BENNET·STREET·SCHOOL

An Education in Craftsmanship

Dear Workshop Participant:

Thank you for enrolling in the North Bennet Street School's **Fundamentals of Fine Woodworking** workshop. The workshop schedule is listed below. Signs will be posted when you arrive at the first class directing you to the classroom.

I have enclosed a list of tools you will need for the class. The brand names noted in parenthesis are the most appropriate for beginning Woodworkers completing projects such as those you will work on in class. While you are not required to purchase these brands, we have found them to give the most predictable results.

You may purchase these tools wherever high quality hand tools are sold. **Woodcraft Supply on Montvale Avenue in Woburn and Rockler's Store on Massachusetts Avenue in Cambridge will give you a 10% discount on the tools if you show them this letter.** Their stock numbers are included on the list; prices are approximate.

These tools can also be purchased at North Bennet Street School through a local vendor , J.I. Joseph Co., on the first day of the class. The prices are very reasonable and the tools have been chosen carefully.

Again, thank you for enrolling in our workshop. We look forward to seeing you in class.

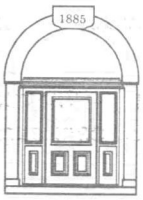
Sincerely,

Janet A. Collins
Workshop Program Director

enc.

Class Dates: **10 Saturdays, Sept. 23 - Dec. 2, 2000**
No class on Nov. 25
Class Hours: **8:30 AM - 4:30 PM**

9/00



39 North Bennet Street
Boston, Massachusetts 02113
(617) 227-0155 Fax (617) 227-9292

Fundamentals Of Fine Woodworking Tool List

NOTE: All prices are approximate. J.I. Joseph Co. will have these tools available on the first day if you are unable to purchase them in advance.

***Safety Glasses - REQUIRED-** some comfortable form of eye protection ("OSHA" approved or "ANSI Z87" rated) such as safety glasses, safety goggles, or impact resistant prescription glasses will be *required.* J. I. Joseph $2.95 pr.

12" Combination Square (Starrett):
Woodcraft 06R12 $72.50
Rockler's 52407 $59.99
J. I. Joseph Co.$52.50

#4 Smooth Bench Plane:
Woodcraft #123401 (Stanley Bailey) $69.99
Rockler's #82701(Record) $59.95 Rockler's #86290 (Stanley Bailey) $60.99
J. I. Joseph (Record) 59.95

1/4", 1/2", 3/4" and 1" Bench chisels:
Woodcraft (Marples) $29.99 set of 4,
Rockler's (Marples) $34.49 set of 4
J. I. Joseph $29.95 set of 4

Dovetail saw (Eberle Blue Blade Saw):
Woodcraft 85U03 $11.95
Rockler's 86290 $14.99
J. I. Joseph $9.95

Card Scraper 6 inch (Sandvik):
Woodcraft 02Z08 $6.50
Rockler's 45161 $9.49
J. I.Joseph $6.95

Sharpening Stone (Norton combination coarse India/fine India 8" x 2" x 1"):
Woodcraft 07A02 $21.99
J. I. Joseph $14.95

Honing Oil: (Norton)4 1/2 oz.
Woodcraft 07010 $5.99
J. I. Joseph $2.99

Marking Gauge:
J. I. Joseph has a cutting gauge for $26.00 and a marking gauge for $15.50. Please talk to your instructor on the first day of class before purchasing a marking gauge.

Mill File (8" smooth) -with a handle
J. I. Joseph $6.95

Burnisher - J. I. Joseph $4.25

REMINDER: If you are planning on purchasing tools on the first day, please bring a check to class as payment. Sorry, we cannot accept credit cards for the tool purchases.

Sequence

Face
Edge
End
End
Edge
face

Matt's

face
Edge
End
End
face
Edge

Rip the board to width last

Cutting gauge gauge - scribe to lowest point

9/23

FUND OF FINE WOOD WORK

JANET COLLINS
MATT WAYDA

NORZON
80 grit
Metal cutting Sandpaper
Silicon carbide

ARKANSAS – SOFT WHITE
HARD WHITE
SURGICAL BLACK

STROPPING – PULL STROKE, ONLY A FEW STROKES

MINERAL OIL OR OIL W/ TURPENTINE

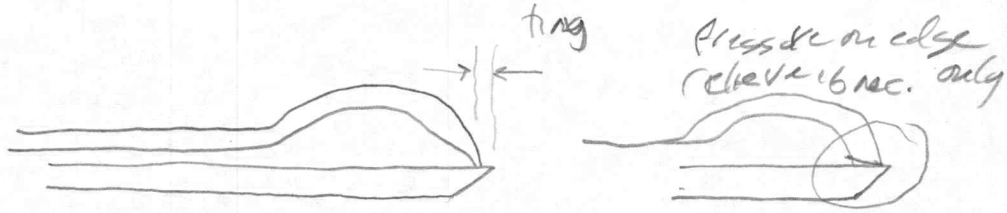
ANNEALING
SHAPING
HARDENING (OIL OR ICE QUENCHED)
HEAT TREATING TO TAN – removing some of the hardness
↳ 600°

JOINING THE EDGE

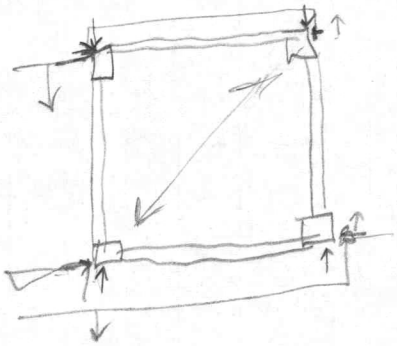
HOLLOW GROUND CHISEL – easier to feel angle on stone than a Flat ground

9/30

NORZON 80 grit Metal cutting Paper



Ensure tray does not rock on its measuring points



10/22

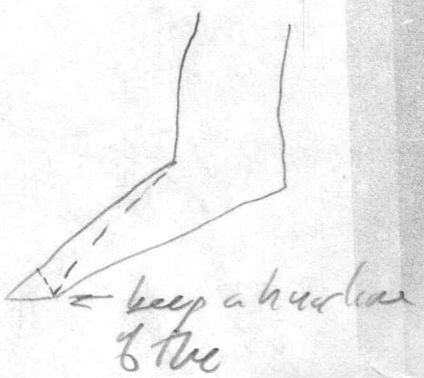
SERVE

Stone is narrower on top
Sketching around; stability

Clapping w/ 1/2 inch
(pencil lines for things that need that fussy)
NOT
SO
Knife lines for accurate lines

Marking Knife

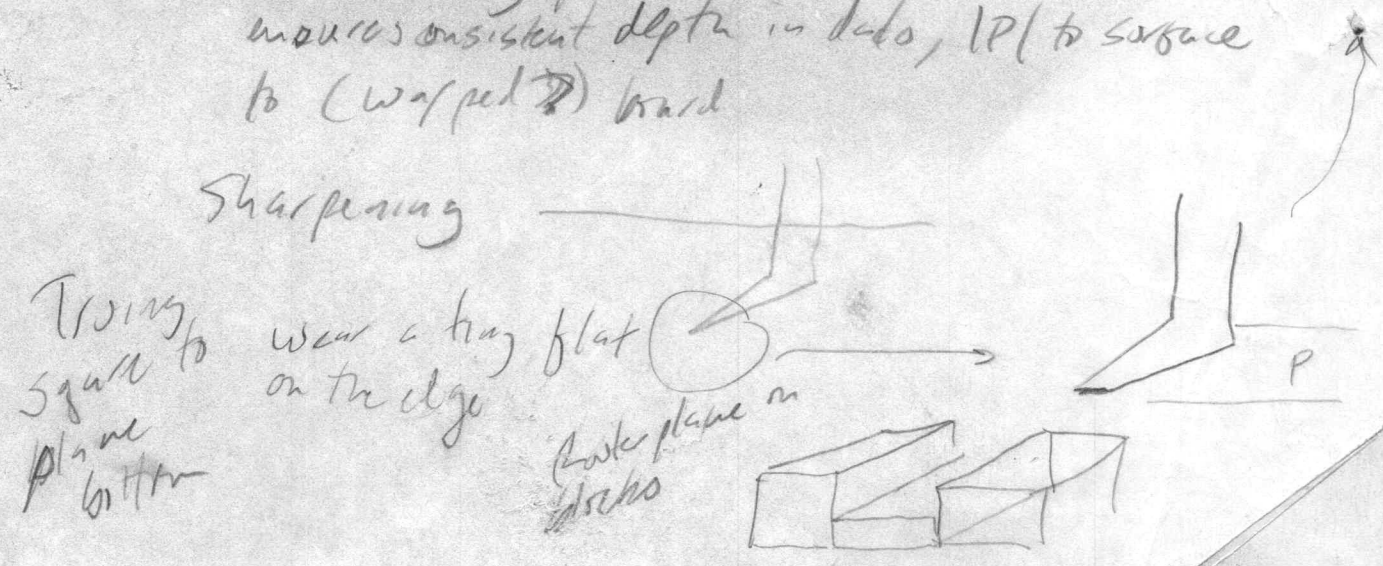
7 1/2 Stanley Rebbet Plane

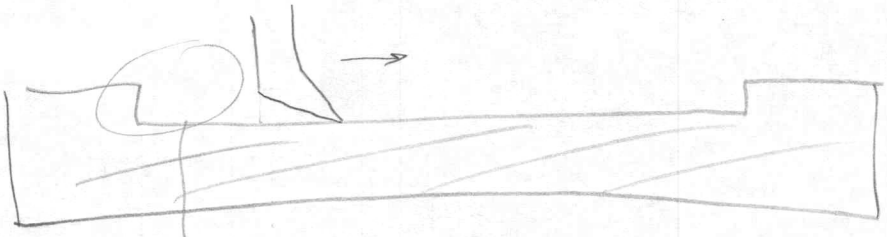


turning up
Excavate surfaces
Work from a reference surface

Use - cleaning up the bottom of a dado
ensures consistent depth in dado, IP(to surface
to (warped) board

Sharpening





Circular screwing motions

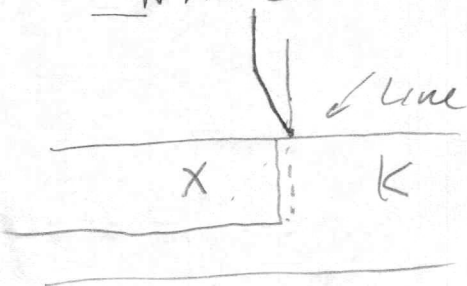
Excavate slightly more than 1/2 stone thickness enough room on the other side

Bookmatch the stone

The bottom of the str box will be built to hold the stone face side up, b/c the back side will be up 90% of the time

Choppings

Work close to the knife line, then pare to it

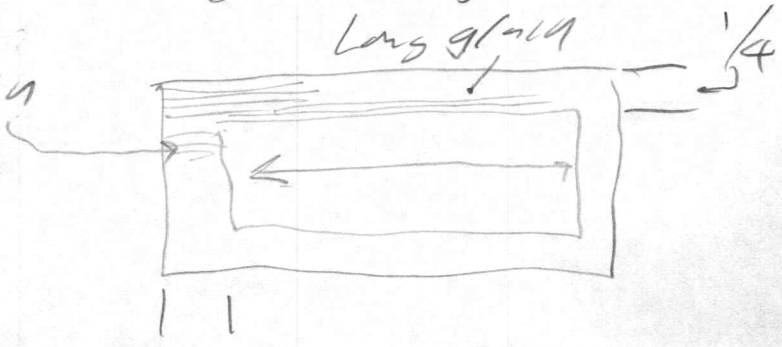


chop near to the knife line pare it off when removing waste is too weak to compress and falls away

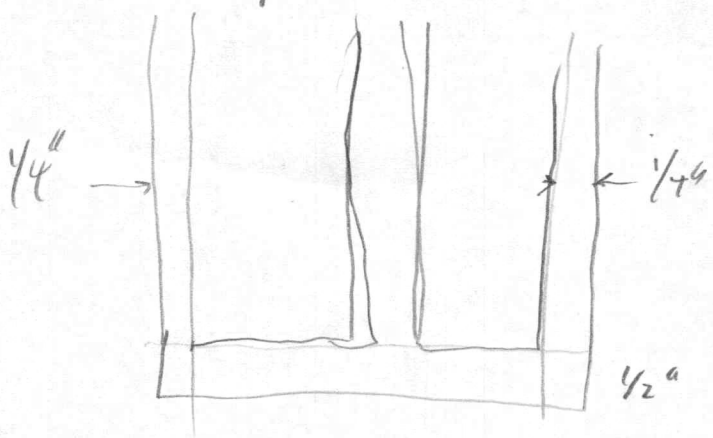
Shoot grain

bevel it up

1/2"



Tactical Legacy:

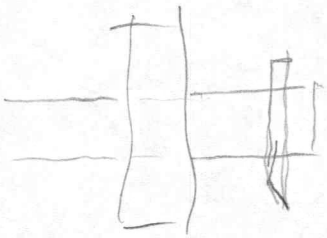


1. Skim the surface w/ sandpaper place the "inside" of the Box will smooth the outside when we're done

SNIPE?

Marking Gauge

bevel towards the fence



2. find a square corner on ~~the Stock~~ the stock the Squarest

Be careful don't wear the square

3 line up the long edge of the stock the & edge line be sure that all of the stock ~~is~~ the end line is within

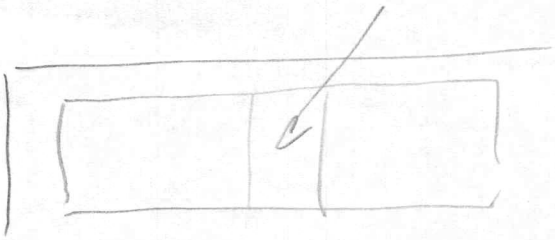
4 Mark the ~~of~~ stock edge on the plank

Multiple light passes - a single heavy pass may have the tendency to ride the grain

5 Scribe a pencil line 1/16" inside of knife line as a reminder

6. Start chopping in the middle chisel edge ⊥ to the grain

7. Rough depth - to within 3/16" of bottom



Remainder with can then be pared to rough depth

8 chopping stb done on bench w/ bench dogs, not in the vise, which is bad for the vise and screws

clamped over a leg

5/16" finish depth

Make please just shy of it

11/4

Cut Mortise first, 1/8" longer than tenon for to accomodate glue squeeze out
also, hollows mortise leaves crumbs in corner

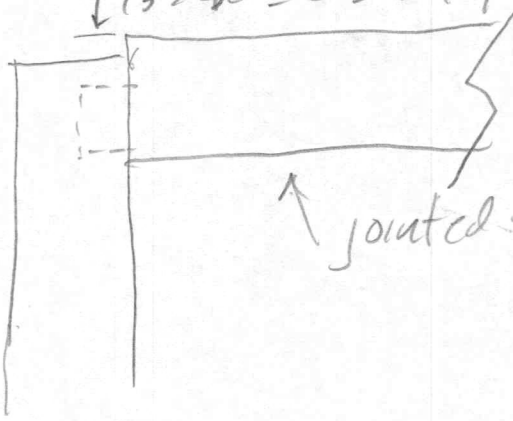
→ cut tenon to fit mortise

ALWAYS use a piece of "scrap" to test
w tenons, to test fit before running all tenons
running

surfaces
references ~~edges~~
face + adjoining edge

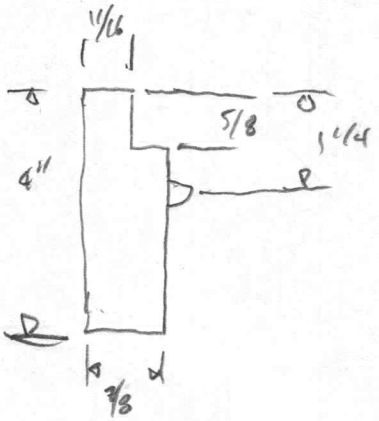
Rail – join jointed edge to inside of structure

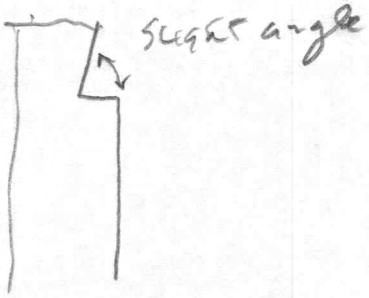
face
1/32 wider – easier to plane rail's long grain than stiles end grain



Bareface off of the bottom

Scribing – get some depth to the cut:
– shoulder line will affect aesthetics





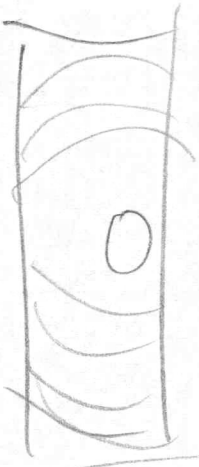
11/12

DOG HOLE: 1/16 larger than a dog

Scrapers — → roll a smooth/aggressive edge

Thinner metal; blue steel shim stock, cut to shape

- Scrape brush marks off of shellac
- Use it one-handed



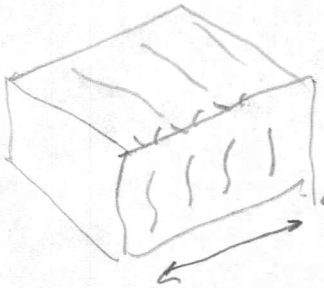
Brentwood Machines

BRENTWOOD, NH

exit 7? east toward portsmouth

BRENTWOOD MACHINES

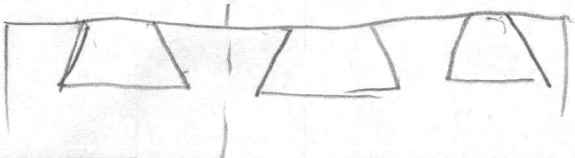
One tail - Concave



grain wraps around pieces this way

Leave room inside on the end of the drawers, b/c when it shrinks it will pull out the drawers

toolbox - Must be cut open along center of a tail to yield two half dovetails

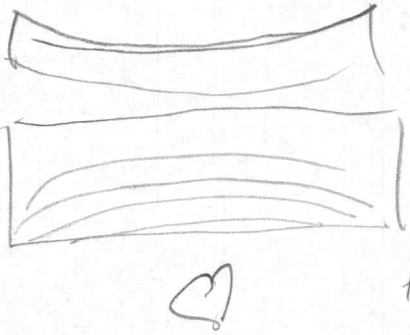


1:8 layout

tails: < 2" wide
or
2.5" wide

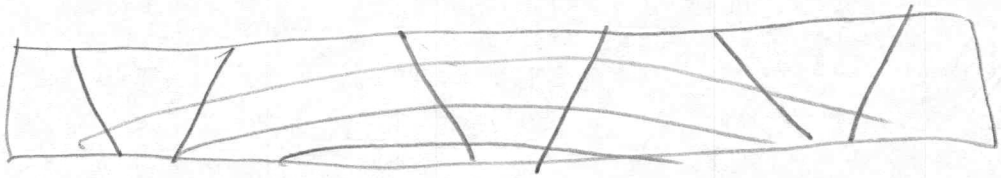
tail checks

± tails
tail size
pin layout, mirrored
which board face out
pins first / tails first
references



tangential
reference
Penny want
to string thru out

Reference faces:
Inside face + Edge



Pin board will squish a little

Pin board with be face ↑ case
pins will compress when fitted
tl CAST faces out
milling – do each board evenly

5/12

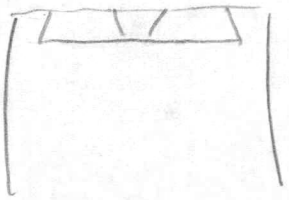
Shoulder Lines - depth of joint
Pins + Tails ends to little bit proud of surface

---

clean up mill marks on inside surfaces

Tail board - push this thing apart

Pin board - no need to mark outside edges



How many pins / How many tails

Space between tails must ~~allow~~ accommodate your smallest chisel

---

Layout Pin board

Reference face toward you

Wide portion of ~~tail~~ pin ~~on far side~~ away from you on near side

Narrow portion of pin on reference face facing you

Wide portion of tail: 5/8" wide 5/16

① Define wide portion width of pin

② Take 1/2 of Define ~~width~~ width and scribe down both edges of reference face

③ Determine # of pins? tails? tails

④ Pick a number easily divisible by the number of tails

Chopping waste
clamp pin board

Nippers pinch end of pin on waste piece

When chopping waste w/ mallet, set chisel inside of scribed shoulder line

10/14

WOOD IS LIKE COTTON — a similar material

12in, give wood 1/8" to move

Reveal?

Summer	12 1/8	Plain Sawn
Winter	12	Quarter Sawn

↳ I need the thickness of my Starrett ruler & space around here

Cherry Honeycombing - Splitting along the Rays
↳ Undulating surface is tell-tale
↳ outside is losing moisture quicker than interior

Air drying: year/inch
↳ Not as good as kiln-dried

Milling in 2 steps — Will decrease my TENSION

Roughing → 2 steps Roughing Finish

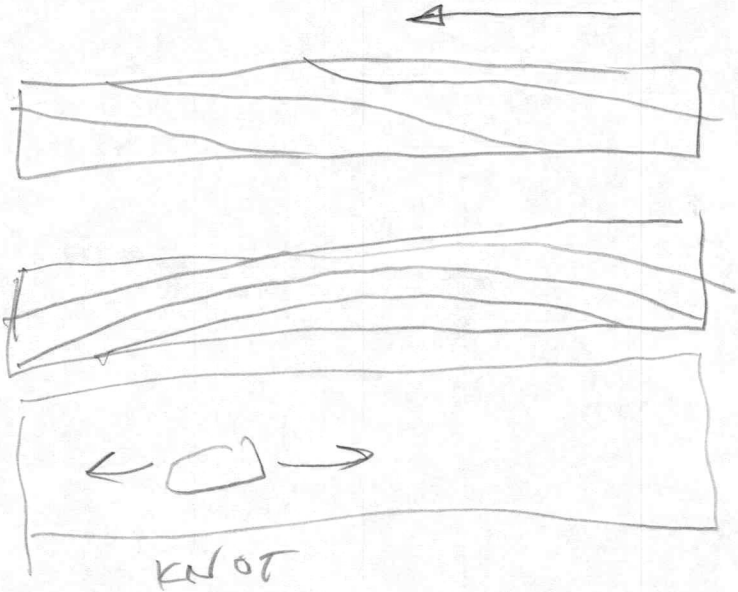
1 over in length
1/2 over in width
1/4 over in depth (thickness)

For longer boards you need more thickness to alleviate twist

↳ Take equal amts off of each face
Flatten (reasonably) one face
Same amt off of 2nd face
Once flat, flip end over end taking off equal amts to end thickness

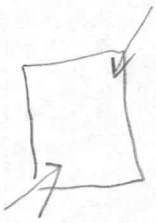
10/7

Flattening a board



FACES |P|
EDGES |P| & FACES
END |P| & ENDS & FACES

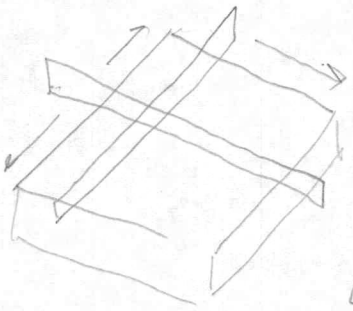
CUP TWIST



BOW across length

Concave SIDE ↑, sets on edges

Take care of
CUP
BOW
TWIST



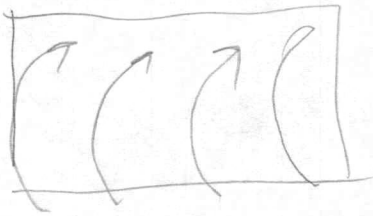
sighting up the board

Determine where the high spot is & take it down

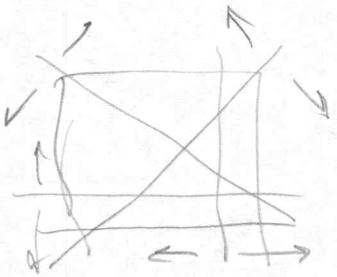
Blade projects a bit more for rough work

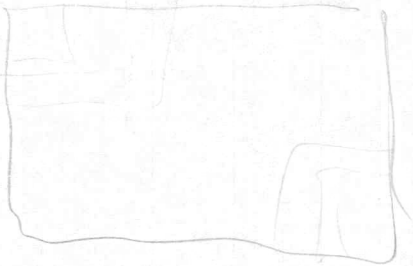
Pressure in front of plane, plane will find the high spot
↓pressure to heel as you crest the rise

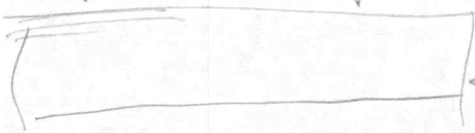
As board trues, edge grain on far edge is not supported
back off on the blade to prevent
tear-out



SKEW IT OFF
OR SLOW IT DOWN





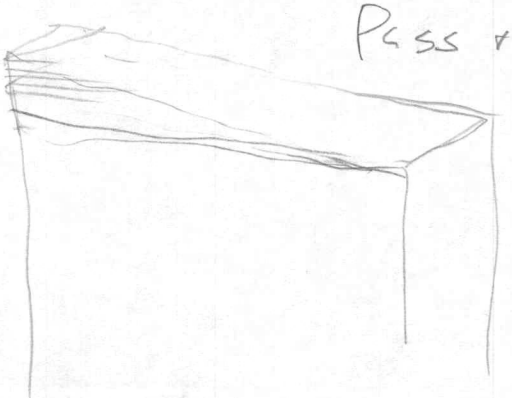


What's the diff
between bi flo
and how many
shavings is
that?

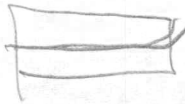
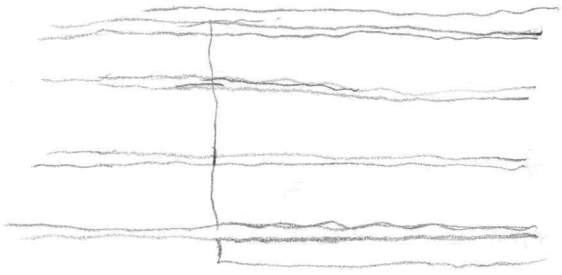
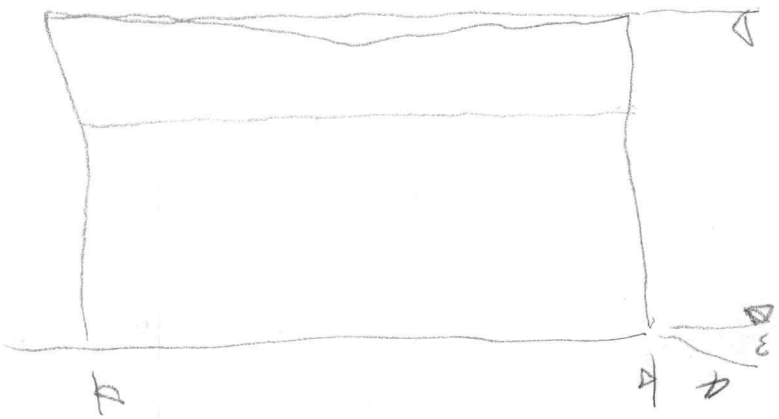
Counting Strokes
Bring the iron back in when you go with the grain

End Grain - close it down

Pass + Lift off.



↓ down force to
stifle chatter



at the edge:
1 slow it + skew it
2 sacrificial block
3 plane from both ends to
center